Pacific Island Network
Vital Signs Monitoring Plan:
Phase III Report

Appendix E: Topical Working Group Report – Landscape

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Pacific Island Network (PACN)

Territory of Guam
War in the Pacific National Historical Park (WAPA)

Commonwealth of the Northern Mariana Islands
American Memorial Park, Saipan (AMME)

Territory of American Samoa
National Park of American Samoa (NPSA)

State of Hawaii
USS Arizona Memorial, Oahu (USAR)
Kalaupapa National Historical Park, Molokai (KALA)
Haleakala National Park, Maui (HALE)
Ala Kahakai National Historic Trail, Hawaii (ALKA)
Puukohola Heiau National Historic Site, Hawaii (PUHE)
Kaloko-Honokohau National Historical Park, Hawaii (KAHO)
Puuhonua o Honaunau National Historical Park, Hawaii (PUHO)
Hawaii Volcanoes National Park, Hawaii (HAVO)

http://science.nature.nps.gov/im/units/pacn/monitoring/plan/

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EXECUTIVE SUMMARY

All parks in the Pacific Island network (PACN) require monitoring of landscapes either inside or adjacent to the park. Most of the PACN parks share similar landscape resources such as ecological gradients and zones, soundscapes, lightscapes, natural and culturally significant resources, viewsheds, management zones and use areas. The larger parks (HAVO, HALE, KALA, NPSA) include designated and potential wilderness areas, which are highly susceptible to anthropogenic noise from air tours. Landscapes are also affected by water quality, land use, light pollution, marine and terrestrial noise, visitor and management impacts.

Monitoring will provide a better understanding of the environmental conditions and information to determine the status and trends of selected vital signs of park ecosystems. Early detection of degraded ecosystems will assist park managers in mitigation efforts, as well as reduce costs for managing landscapes with associated natural resources. Landscape monitoring also provides information on the effects of natural and anthropogenic processes occurring in parks. Monitoring is also essential for the protection of important resources that share cultural and natural value.

The PACN covers an enormous area across the northern and southern hemispheres on both sides of the International Date Line (see map on pg.16). Hawaii is located between 19 and 22 degrees north latitude and situated almost directly in the center of the Pacific Ocean (Juvik & Juvik 1998). Due to its isolation from a larger continental region, natural resources are quickly affected by external activities. Guam, located at 13 degrees north latitude is the largest and southern most of the Mariana chain and part of Micronesia, is 32 miles long and four to nine miles wide. The climate is tropical and is influenced by the northeast trade wind regime. Saipan, also part of Micronesia, is situated at 15 degrees north latitude slightly above Guam (125 miles). Saipan is 14 miles long and 4 miles wide, (approximately 47sq miles), and by the standards of Micronesia it is considered to be a sizable island. The climate is tropical and Saipan is also influenced by the north east trade regime. American Samoa includes five volcanic islands (Tutuila, Aunu'u, Ofu, Olesega, Tau) with a total land area of 76.1 square miles. These islands are located 14 degrees south of the equator. The climate is hot, humid with year round rain and is influenced by the south east tradewinds. The highest elevations are on Lata Mountain located on the island Tau (3,100 feet) and Matafao Peak (2,142 feet),on the island of Tutuila.

One of the unique aspects of the landscape topic is its interaction with natural resources issues and cultural value. The interface of natural resources and cultural values can create a conflict of interest while trying to preserve resources and provide for the enjoyment of future generations. The drivers and stressors affecting landscapes have been identified as both natural and anthropogenic. However, most of the threats affecting landscapes are human induced. They include, but are not limited to, air tours, increased development, subsistence agriculture and fishing, fires, adjacent land use encroaching on park units, light pollution, litter, introduction of alien species (both plant and animal), and visitor impacts.

Some of the needs for the PACN monitoring program regarding landscapes are oral histories from local residents to establish long term trends of subsistence agriculture and fishing. This information is useful in gain a better understanding of pre-European contact of the Pacific Islands. Complete vegetation mapping for all PACN parks to identify native and alien plant species is needed to document terrestrial resources and rapidly respond to changes occurring.

Determining the status of cultural resources is also needed as some of these resources are largely responsible for the sustenance of the natural environment.

Partnerships with adjacent landowners to assure contiguous landscapes are vital for all PACN parks. Monitoring land use and land use activities within the parks is essential to preserving natural resources. Some parks have complicated land ownership or lease agreements with local governments that provide NPS with the opportunity to manage land that would otherwise be unattainable.

This document is intended to provide information to resource managers on the status of landscape resources and issues affecting the resources. The document also contains current knowledge of landscape monitoring in PACN parks and other regional monitoring programs related to landscape issues that could be adopted by the National Park Service.

INTRODUCTION

SCOPE OF TOPIC AREA

The landscape topic as covered in this report encompasses natural ecosystem processes that incorporate cultural values and perceptions across multiple scales. The landscape topic incorporates environmental stratification into monitoring site selection (environmental gradients, management zones, cultural resource datasets, human impacts), to ensure that site selection is as unbiased as possible based on the criteria desired when selecting sites and that the appropriate or desired resource characteristics are included. Drivers and stressors that affect landscape issues are identified by two categories in this report: natural and anthropogenic.

BACKGROUND

Given the PACN monitoring goal to "provide data to better understand, protect, and manage important resources that share cultural and natural value", one of the important roles for the landscape report is to improve integration of natural and cultural resource information sources. Examples of this are many. For broad scale ecosystem structure, function, and composition, this may mean coordinating within-park species-of-interest monitoring (native or alien) with changes in land use practices by other landowners within or nearby. With the diverse array of human activities and their integrated relationship to natural resources within NPS sites throughout the PACN, a careful review of both cultural and natural resource issues for either program area is needed.

Many of the natural resource issues in the landscape workgroup are regulated at a political level, with the state or territory often being the highest level of authority. As such, the Territory of American Samoa, Territory of Guam, Commonwealth of Northern Mariana Islands, and State of Hawaii are often treated independently for the context of this workgroup. For some topics, regulation may be at a county level, and regions for these issues are addressed accordingly.

MONITORING GOALS AND OBJECTIVES

A majority of PACN parks have indicated that potential synergies between NPS 'natural' and 'cultural' resource disciplines should be a priority for the monitoring program. Accordingly, the PACN Monitoring Program established a goal to "provide data to better understand, protect, and

manage important resources that share cultural and natural value". This landscape report is, in part, intended to help incorporate the cultural resource interface with natural resource issues. A few examples of how such data may be used by management include:

- Partnering with adjacent landowners to assure monitoring occurs across multiple environmental gradients, cultural landscapes and management zones.
- Monitor the role of land use activities in accelerating or hindering the distribution of non-native species (especially invasive species), modifying water quality and quantity conditions, and modifying viewsheds and topography.
- Incorporate cultural landscape, ethnographic, archeological site inventory information, along with management zones, and other variables into monitoring site selection decisions.
- Monitor effects of land use activities on natural resources and cultural values that Park administrators view as being beneficial to visitors.

LEGISLATION AND POLICY

As a federal agency, the NPS operates under a hierarchy of legislative mandates, including federal laws, executive orders, Department of the Interior and NPS policies and directives, as well as county, state, commonwealth, and territorial regulations. Further, management of submerged resources is complicated by jurisdictional or administrative issues that are often managerially more challenging than similar issues on land. These complexities require the NPS to cooperate with numerous and often overlapping federal and local agencies to achieve its objectives.

I & M - NATURAL RESOURCE CHALLENGE

The Natural Resource Challenge (NRC), initiated in 1999, is an action plan for preserving natural resources through the National Park Service (NPS). The NRC assisted NPS to establish 32 Inventory and Monitoring networks, which includes 270 National Parks. In the Networks, parks are grouped that share geographical and natural resource characteristics. The Inventory and Monitoring (I&M) Program is designed to first complete basic inventories of natural resources in parks, on which to base long-term monitoring efforts. Monitoring programs are based on monitoring critical parameters (Vital Signs) within each network to incorporate into natural resource management and decision-making. "Vital Signs are measurable, early warning signals that indicate changes that could impair the long-term health of natural systems" (NPS, 2003).

The NRC and Inventory and Monitoring program emphasize integrated information systems for all NPS programs. The 'landscape' workgroup is a direct effort to address these integrated needs. Examples of how this integration can occur are through a deliberate 'environmental stratification' process when selecting monitoring sites and in making use of NEPA documents and processes that must also address a broad suite of issues.

LANDSCAPE RELEVANT LEGISLATION

This section reviews applicable general legislation, park enabling legislation, NPS and park specific management policies http://www1.nature.nps.gov/im/units/pacn/pacn_policy.htm and

local regulations. Among the basic scientific tenets of a landscape approach in ecological monitoring are gradients and ecozones, where there is very little legal mandates.

One analogy of how general legislation can afford partnerships in conservation monitoring is the National Natural Landmarks (NNLs) program. The NPS seeks to periodically verify the condition of NNLs and maintain good rapport with landowners--to comply with 90 Stat. 1940; U.S.C. 1a-5. This law requires monitoring of the condition of NNLs in order to prepare an annual report for the Secretary of Interior to transmit to the Congress identifying all designated NNLs with known or anticipated damage or threats to the integrity of their resources, and the source of such threats or damage. This report has been commonly referred to as the "Section 8" report. Within the Pacific Island Network, NNL partnerships range from Mauna Kea, Hawaii ('…exposed portion of the highest insular mountain in the United States, containing the highest lake in the country and evidence of glaciation above the 11,000-foot level. Most majestic expression of shield volcanism in the Hawaiian Archipelago, if not the world.') to Puntan Dos Amantes, Guam ('…illustrates the limestone deposition and subsequent subterranean erosion phases of Guam's geologic history. The area contains a 370-foot high cliff exposure of massive limestone.').

NPS

Park Enabling Legislation

Enabling legislation identifies a variety of resources, including: perpetuation and appreciation of traditional cultures, archeological resources, educational purposes, traditional subsistence uses, connecting communities and historical events, ecological balance, scenic resources, and historic values and objects. All of the PACN parks have both significant natural and cultural resources applicable to the landscape workgroup topics.

Park Enabling Legislation may address specific issues in some cases, such as designating wilderness in HAVO and HALE, or more generally address resources.

- WAPA—to commemorate the bravery and sacrifice of those participating in the campaigns of the Pacific Theater of WWII and to conserve and interpret outstanding natural, scenic, historic values, and objects on the island of Guam for the benefit and enjoyment of future generations.
- AMME—The park shall be administered for the primary purpose of honoring the dead in the World War II Mariana Island Campaign. The inland mangrove-wetland complex is unique to Saipan, as well as to the Pacific Island Network. The Amme mangrove wetland has approxiamately 200 species of plants and animals, including two endangered species of birds, the nightingale reed-warbler (*Acrocephalus luscinia*) and the Mariana common moorhen (*Gallinula chloropus guami*), and the SOC humped tree snail (*Partula gibba*).
- NPSA—preserves the only undisturbed mixed species paleotropic rainforest in the United States. Contains the habitat of one of the last remaining populations of Pacific flying foxes, which is responsible for a large part of the pollination of vegetation that maintains a significant portion of the species inhabiting the Samoan tropical forest.

- USAR—also a (National Historic Landmark) contains submerged cultural resources. The memorial is operated and maintained by NPS in a use agreement with the U.S. Navy.
- KALA—to preserve and interpret the Kalaupapa settlement for the education and inspiration of present and future generations. The isolated peninsula provides habitat for threatened and endangered species (e.g. Hawaiian monk seal pups), which require solitude.
- HALE— enabling legislation states that regulations shall be made and published that preserve from injury all timber, birds, mineral deposits, and natural curiosities or wonders within, and retained in their natural condition as nearly as possible. This legislation has been interpreted to include natural soundscapes, scenery, lightscapes, wilderness, and other topical areas being addressed by the landscape workgroup.
- ALKA—the 175 mile corridor is designated a National Historic Trail to preserve, protect, and interpret traditional Native Hawaiian culture and Natural Resources. Enabling legislation identifies that all significant natural, cultural and historical resources be preserved.
- PUHE—preserves both prehistoric and historic resources. The heiaus are significant resources that facilitate interpretation of ancient Hawaiian religious practices, architectural designs, construction techniques, political activities and lifestyles.
- KAHO—provide a center for preservation, interpretation and perpetuation of traditional native Hawaiian activities and culture, and demonstrate historic land use patterns.
- PUHO—stabilize and preserve resources to protect integrity. Expansion of existing park boundary is proposed in an effort to protect and preserve additional cultural resources.
- HAVO—enabling legislation states that regulations shall be made and published that preserve from injury all timber, birds, mineral deposits, and natural curiosities or wonders within, and retained in their natural condition as nearly as possible. This legislation has been interpreted to include natural soundscapes, scenery, lightscapes, wilderness, and other topical areas being addressed by the landscape workgroup.

The subsequent sections are organized in a hierarchical fashion using the following format; Federal, NPS and Regional if applicable.

ECOLOGICAL GRADIENTS & ZONATION

There is little direct legislation affecting ecological gradations. Where legislation does exist, it is likely based on existing land use practices which may be correlated with ecological gradients.

NPS Management Policies emphasize management zones and habitat types that have historically been of resource interest (wetlands, karst regions, floodplains, and watersheds).

Park management policies typically do not emphasize ecological zones, although designated management zones often correspond to the ecological integrity of selected areas of a park.

No local regulation are known, beyond coastal and watershed protection clauses.

SOUNDSCAPES

The "National Park Service Overflights Act of 1987" (P.L. 100-91) and "National Parks Air Tour Management Act" (P.L. 106-181, Title VIII) are legislative efforts to mitigate or prevent significant adverse soundscape impacts from air tours. Implementing this legislation has identified a two fold concept of sounds: the frequency of occurrence and the decibel noise level (DNL). FAA and military monitoring has typically focused on DNL threshold. Limited monitoring may leave a resource impaired.

Additional legislative references, that apply to a complete array of potential sources of noise, can be obtained from the HAVO and HALE soundscape management plans (in development as of early 2003).

Park enabling legislation that identifies solitude, quiet, or wilderness characteristics may provide the strongest foundation for addressing noise and soundscape issues.

NPS management policies emphasize preservation of natural soundscapes. Natural soundscapes are the aggregate of all natural sounds (within and beyond the range of human) within a park, together with the physical capacity for transmitting natural sounds, through air, water, solid, or other materials. "Director's Order #47: Soundscape Preservation and Noise Management", identifies planning goals. This order also identifies inventorying and monitoring the soundscape as essential to understanding the relationship between the baseline natural soundscape and human-made components of the soundscape--existing and proposed. This information (1) makes it possible to better understand the resource that needs to be protected and the appropriate and inappropriate sources of noise; (2) enables a park to define acoustic goals for different parts of the park, and to determine the nature and level of impacts; and (3) suggests where management intervention can most effectively contribute to protecting park resources and improving the visitor experience consistent with park purposes. Monitoring over time will allow measurement of progress toward defined acoustic goals.

These NPS soundscape policies do not clearly communicate that underwater/marine soundscapes are on equal footing with terrestrial issues, and that sounds from non-native (invasive or exotic) species are also impacts that represent 'inappropriate noise', or 'non-natural sounds'.

HALE and HAVO are in the process of developing soundscape plans consistent with NPS Management Policies. Of special note is also KALA, with a commercial airport within park boundaries under the jurisdiction of the FAA and the Hawaii Department of Transportation, and KAHO, USAR, and WAPA which are all in the vicinity of large airports. (The FAA approved HAVO heliport will be addressed as part of the HAVO soundscape plan).

While municipalities may have noise regulations, 36 CRF Section 2.12 Audio Disturbances, provides additional regulation on federal property. It is also expected that Department of Transportation and FAA regulations (and agreements with parks) for local airports are relevant for aircraft related noise.

LIGHTSCAPES

The George Wright Forum (Vol 18, No. 4, 2001; http://www.georgewright.org/pubslist.html, visited 01/29/03) dedicates this entire issue to protecting dark skies. A review of applicable/example legislation is provided therein. Air pollution also affects lightscapes, with the potential to both limit and enhance the propagation of light pollution. The clean Air Act

(CAA) can also be interpreted to address light pollution and is discussed in the Air Quality/Climate report in the Supplemental Documents.

NPS management policies identify that the service will protect natural darkness and other components of the natural lightscape in parks—working in cooperation with visitors, neighbors, and local government agencies to achieve these goals.

Park specific policies would likely be a combination of Maintenance/Facility Management documents (for developed areas) and Resource Management documents and practices in areas where such concerns have been identified (such as for turtle or seabird habitats). No documents addressing park policies regarding lightscapes have been identified.

Hawaii County Code—Chapter 14, Article 9. Outdoor Lighting (enacted Ord. No. 88-122, sec. 3, in 1988), specifies timing, shielding, and wattage/lumens requirements for outdoor lighting. More restrictive lighting practices are implemented in selected locations, such as on Mauna Kea in the vicinity of the astronomical observatories. The County of Maui proposed an updated ordinance, but it was not enacted. Oahu County currently has a lightning ordinance regulating outdoor lighting use. House Bill 1743 the so called "light pollution bill" is currently awaiting approval by legislation, which would prohibit artificial light from shining into the ocean unless authorized and required for public safety or ocean navigation.

American Samoa, Guam, and Commonwealth of the Northern Mariana Islands currently have no lighting ordinances regulating outdoor lighting.

VIEWSHEDS & SCENERY

The NPS Organic Act identifies "scenery and the natural and historical objects therein" as resources. This has evolved, at least in part, to mean viewsheds and scenery. Scenic qualities have also been addressed through the Clean Air Act and amendments.

Scenery, enjoyment, appreciation, and inspiration are common purposes identified in park enabling legislation that may pertain to this topic.

NPS management policies identified in Reference Manual #77, Natural Resource Management (http://www.nature.nps.gov/RM77/, visited 1.9.2003), identify National Park Service Mandatory Class I Area Integral Vistas: Haleakala NP, Red Hill Observatory (observation point), 280º - 320º and 120º - 165º (view angles) and Hawaii Volcanoes NP, Hawaii Volcanoes Observatory (observation point), 220º - 350º (view angles). There are no regulations requiring special protection of these integral vistas, but the Service will strive to protect these park-related resources through cooperative means. Communication (cell phone) towers are another issue that often affect scenic vistas, and are regulated through NPS policy.

Park specific policies allow a variety of additional scenic views to be identified through Cultural Landscape inventories, historic maintained views established through maintenance programs, or other less formal designation.

Local regulations may be significant when a viewshed originating from within a park includes private or other land governed by local regulations.

LAND USE

Legislation that permits the NPS to address external threats, protect lands, or adjust boundaries is pertinent. Other legislation may apply to within-park 'land use' activities, such as wetlands legislation or in relation to archeological sites.

Park enabling legislation for KAHO and ALKA both identify traditional land use or land use practices as park purposes.

NPS management policies identify the need for land protection plans for lands or interests in public ownership, and provide guidance on cooperative efforts with neighboring jurisdictions for the protection of park resources.

Park management policies may vary based on previously identified needs—for example, HALEs history of interest in airport expansion and changes in ranching management practices may not be similarly expressed in other park management policies.

Local regulations incorporate a wide array of issues, from zoning, coastal zone management programs, specific commercial uses such as airports, to building codes governing catchment tanks, or agricultural pesticide policies. There are no local land use regulations pertaining to NPS units.

CHEMICAL INFORMATION & ODORS

Legislation regarding chemical information & odor is often addressed through the Clean Air Act and amendments. No specific legislation tied to this topic was identified.

Park enabling legislation would likely be applicable through reference of the general preservation and protection of resources, although no specific enabling legislation was identified.

NPS management policies state that the service will preserve, to the greatest extent possible, the natural flow of natural chemical information and odors—while acknowledging that its own activities may disrupt these processes. The service will comply with all applicable laws, regulations, and policies, and seek to minimize harm to the environment.

The park service may take action to inhibit the natural chemical composition with varying techniques.

Local regulations pertaining to water quality & solid waste regulations may be most pertinent to chemical information & odor.

MANAGEMENT ZONES—USE AREAS

Legislation related to park management zones or use areas is most likely to be applicable through the Wilderness act or coastal zone legislation, although no explicit legislation has been identified.

"Director's Orders #82: Public Use Data Collecting And Reporting Program", is to set forth policy and procedures for collecting and reporting public use data at the units of the National Park Service. The objectives of the program are to design a statistically valid, reliable, and uniform method of collecting and reporting public use data for each independent unit administered by the National Park Service (NPS); to enact a variety of quality control checks to eliminate errors; to provide analysis and verify measurements of the public use data, to assure

consistency of data collection within areas of the NPS; and to support the continuous collection and timely publication of public use data.

Park enabling legislation may correlate with management zones based on purpose, especially where traditional land use practices are identified such as at KAHO. Also, management zones may reflect the parcel acquisition history of the park, and as such, having spatial data detailing previous landowners and the parcel acquisition process is essential.

NPS management policies identify that park GMPs will delineate management zones where there are differences in intended resource conditions, visitor experience, and management activity.

Park Management policies have identified management zones, although the terminology and definitions may differ slightly among PACN parks. This identification is prescribed by the individual park's General Management Plan.

Cultural based designations include wilderness (HALE & HAVO), historic districts, and traditional use areas.

Natural designations include: Special Ecological Areas (SEAs) (HAVO & HALE), Research Natural Areas (HALE). SEAs are priority places designated for intensive management, including control and removal of exotic species.

Ecological zones are often designated through Threatened or Endangered Species management plans, for example where seabird nesting areas corresponds with general ecological zones or habitat types. Hawaii ecological zones have been delineated from elevation, alpine zone >9,000 feet with the highest point, 13,796 feet, located on the summit of Mauna Kea on Hawaii Island, the subalpine zone ranging between (6,000-9,000), montane (3,000-6,000), lowland (0-3,000), and the coastal zone (0-100) feet (Juvik & Juvik 1998). Ecological zones for Guam are based mainly on the substrate of the landscape, with the northern region comprised primarily of limestone and the southern part consisting of volcanic soils. The ecological zones for NPSA are relative to elevation, rainfall, and type of vegetation. This is evident in the strand, shrubland, forest, and rainforest communities. These zones have been recognized for the PACN parks but from a global perspective the World Wildlife Fund (WWF) scientists have designed the Global 200, which is a scientific ranking of more than 200 critical terrestrial, freshwater, and marine habitat areas. This ecoregional approach seems to be the most appropriate for the Pacific Islands Network given the large scale geographic range it encompasses.

The Wilderness Act (P.L. 88-577) provides the basic guidelines for wilderness. NPS Management Policies, "Director's Order #41: Wilderness Preservation and Management", and "Reference Manual 4" provide NPS specific guidance. This includes various categories for consideration, including designated wilderness (so designated by Congress), recommended wilderness (by the Secretary of the Interior to the President), and potential wilderness (requiring removal or elimination of non-conforming uses). In addition, parks may identify in the course of wilderness studies, areas suitable as wilderness and buffer zones that need to be maintained to protect existing or potential wilderness. NPS Management Policies require monitoring of conditions and long-term trends to identify the need for and effects of management activities.

HAVO and HALE are the only 2 parks with legally designated wilderness. In addition, the general policy of the NPS is to support scientific activities in wilderness, and to use science to improve wilderness management. Moderate sized parks (especially NPSA and KALA) incorporate areas that may be managed similar to wilderness areas, and provide similar resource

benefits for the scale of their island landscape. NPS management policies states a formal wilderness study may identify park lands that are being recommended for immediate wilderness designation, as well as any other lands identified as "potential" wilderness.

ECOLOGICAL CONTEXT

GEOGRAPHY

All the network parks are found on tropical islands in the Pacific Ocean. Eight of the parks are in the Hawaiian Islands in the Central Pacific between 19 and 22 degrees North latitude. HAVO, KAHO, PUHE, PUHO, and the recently designated ALKA are on the island of Hawaii, the youngest of the main Hawaiian Islands at the southern and eastern end of the archipelago. HAVO is located on the southeast slope of Hawaii Island, where it extends from sea level to the summits of Kilauea and Mauna Loa Volcanoes. The newly designated Kahuku unit of HAVO is positioned on southern Mauna Loa and extends down both the eastern and western flanks of the volcano. PUHE, KAHO, and PUHO are coastal parks on the western side of the island; KAHO is centrally located with PUHE to the north and PUHO to the south. HALE is on Maui, the second youngest Hawaiian Island; HALE extends from sea level to the summit of East Maui. KALA is on a peninsula projecting from the north shore of Molokai, centrally located in the main Hawaiian Islands. USAR is within Pearl Harbor on southern or leeward Oahu. Two PACN parks are situated in the western Pacific Ocean between 13 and 15 degrees north latitude in Micronesia. WAPA is on the western side of the island of Guam and AMME is on the west coast of Saipan, one of the Northern Mariana Islands. NPSA (14 degrees S) is located on the Polynesian islands of American Samoa. One unit of NPSA is on the island of Tutuila; three others are on Tau, Ofu, and Olosega of the Manua Island group 96 km (60 miles) east of Tutuila.

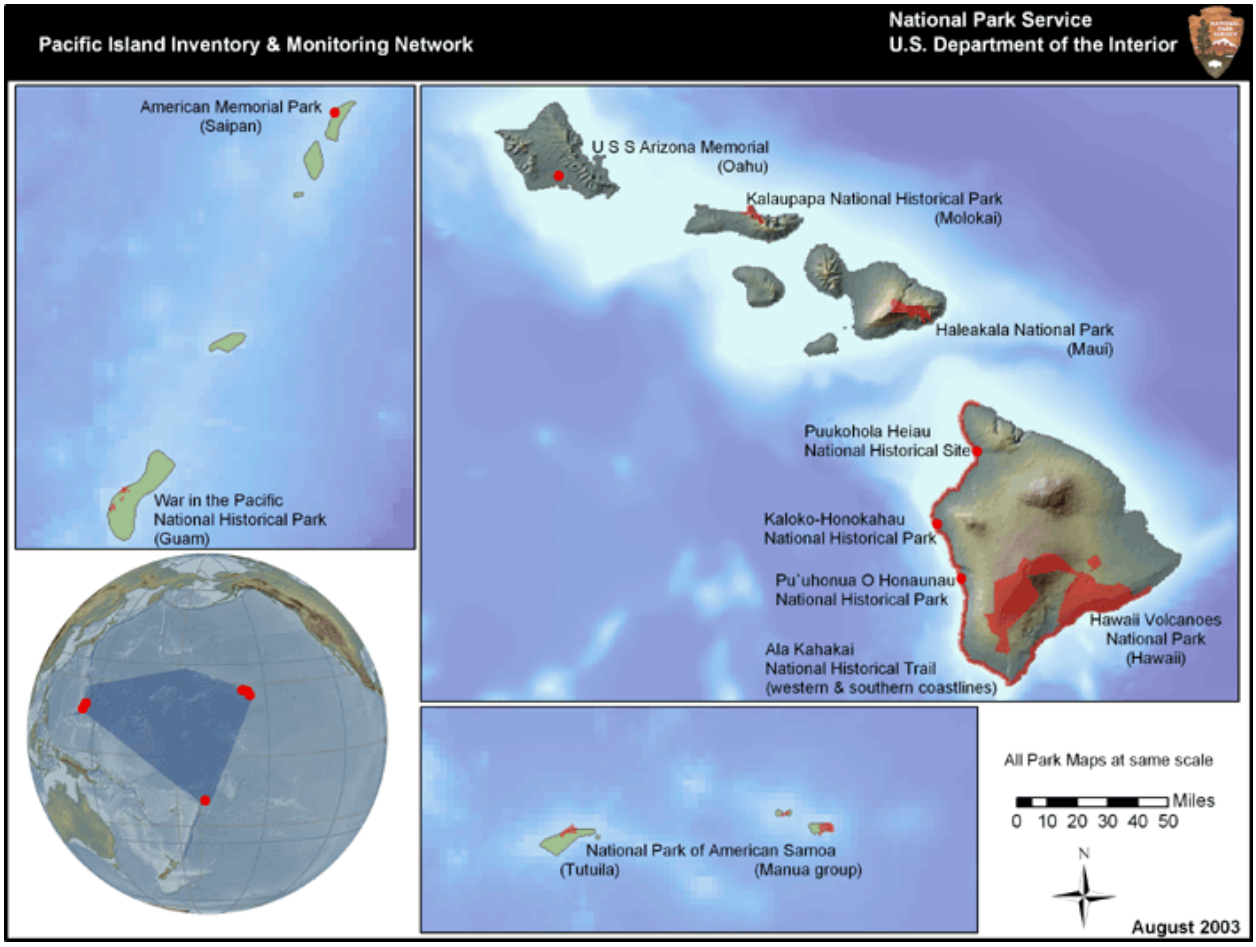

Figure 1. Pacific Island Network National Parks

GEOLOGY

The parks of the Western Pacific (WAPA, AMME) are on islands (Guam and Saipan) with long-extinct volcanoes. These islands have complicated geologic origins involving both volcanism and subduction of the Marianas Trench. The northern half of Guam and portions of Saipan have limestone substrates elevated above a weathered volcanic base. WAPA units are on the volcanic substrates of the southern half of Guam, but at least one unit includes elevated limestone caps.

The islands of American Samoa and Hawaii are oceanic volcanic islands arising from hotspots. The oldest of the Samoan Islands are dated at more than two million years, but there was volcanic activity between Tau and Olosega approximately 150 years ago (Whistler 1994). In Hawaii, HALE protects the summit of the inactive Haleakala Volcano and its impressive crater, which is the result of stream erosion, the merging of Kaupo and Keanae Valleys, and subsequent volcanic activity. KALA encompasses the Kalaupapa peninsula, formed on the north shore of Molokai during the Pleistocene (MacDonald and Abbott 1970). The volcanoes of both Molokai and Oahu are extinct.

The five parks on Hawaii Island are on active or dormant volcanoes. A significant portion of HAVO is covered with recent lava flows that are sparsely vegetated. HAVO also contains the rift zones and summit calderas of both Mauna Loa and Kilauea Volcanoes, two of the most

active volcanoes on earth. PUHO is on prehistoric pahoehoe flows of Mauna Loa, and PUHE substrates are old weathered soils of Kohala Volcano. All substrates of KAHO are flows from Hualalai Volcano less than 10,000 years old, including one sparsely-vegetated lava flow dated at 1,000-3,000 years (Moore et al.1987).

ELEVATION GRADIENTS

Among the Hawaiian parks, HAVO and HALE have the greatest elevational range, extending from sea level to the summits of tall volcanoes >3,000 m (>10,000 ft) in elevation. KALA has an elevational range from sea level to almost 1,220 m (4,000 ft) elevation. The three parks of leeward Hawaii Island are coastal parks and extend upslope to an elevation no more than 100 m. ALKA is also in the coastal lowlands of western and southern Hawaii Island.

Among the three Western Pacific parks, AMME is restricted to coastal lowlands on the western shore of Saipan. WAPA includes both coastal units and inland sites on the slopes of Mt. Alifan and Mt. Tenjo; one unit extends to above 305 m (1,000 ft) elevation. NPSA is composed of four units; Ofu and Olosega are largely coastal but the Tutuila and Tau units range from sea level to 491 m (1,610 ft) and 966 m (3,170 ft) elevation, respectively.

RAINFALL AND CLIMATE:

The largest two Hawaiian parks, HAVO and HALE, include within their boundaries several climatic zones with a range of rainfall regimes. HAVO contains two of the four rainfall minima of Hawaii Island, the Kau Desert with mean annual rainfall <750 mm and the interior lands of Mauna Loa with <500 mm annually. The highest mean annual rainfall within the park is found in Olaa Tract, a rain forest with >4,000 mm per year (Giambelluca *et al*. 1986). In general, the eastern windward portion of HAVO has high rainfall, which diminishes upslope, particularly above the trade wind inversion layer near 1,830 m (6,000 ft) elevation. The upper elevations of the park are moist to very dry, and the summit of Mauna Loa receives on average <500 mm precipitation. The leeward, western portions of HAVO are in rain shadows of Mauna Loa and Kilauea summit, and are typically dry.

HALE also has a range of climates, as it extends from sea level on the windward, eastern slope of Haleakala to the summit of East Maui. This park also includes lands in the leeward rain shadow of Haleakala, down to 1,220 m (4,000 ft) elevation. Annual precipitation in the park varies from 1,250 mm in the Crater, southern slope, and Kaupo Gap to >6,000 mm on the upper northeastern slopes of Haleakala. KALA, on the north shore of Molokai receives 1,000 mm of precipitation annually at sea level and >3,000 mm at the upper elevations of Waikolu Valley (Giambelluca *et al*. 1986). USAR on Oahu is located within Pearl Harbor on the dry leeward side of the island in an area than has on average 600 mm rainfall per year.

The four West Hawaii Island parks are in relatively low rainfall areas with constant warm temperatures and pronounced daily wind patterns of land and sea breezes (Blumenstock and Price 1967). KAHO has a mean annual rainfall of approximately 600 mm and a seasonal climate with higher rainfall during summer months (Canfield 1990a). The climate of PUHO is similar to that of KAHO, with mean annual precipitation of 659 mm. PUHE is located within one of the four rainfall minima of the island of Hawaii and receives<250 mm of rain annually (Giambelluca *et al*. 1986).

The climate of Guam and the Northern Marianas (CNMI), including Saipan, is warm, wet, and tropical. Temperature varies between 90 and 70° F. Relative humidity is high, often exceeding 80% and seldom falling below 50%. The rainfall pattern is strongly seasonal with a wet season from July to November and a pronounced dry season from December to June. Average annual rainfall of the Marianas is 2,160 mm (85 in) (Baker 1951), and on Guam the annual mean is 2,175 mm (Mueller-Dombois and Fosberg 1998). Typhoons are yearly events, which occur during the monsoonal wet season. Trade winds blow from the northeast, but easterly and southeasterly winds prevail during several months in the spring (Baker 1951). Because Guam and the Marianas are relatively low islands, there is no pronounced rain shadow effect, and leeward shores are not drier than those of the windward sides (Mueller-Dombois and Fosberg 1998).

NPSA has a warm tropical climate with little seasonal variation in temperature. Rainfall is high in the four units of the park. On Tutuila, annual rainfall averages 3,200 mm (125 in) (at the airport), with an additional 3,150 mm (124 in) in the Tau Unit. Rainfall is seasonal with greater monthly means from October to May and a dry season from June to September. Hurricanes are occasional but not annual events (Whistler 1994). Tau Island unit is only about 96 km (60 miles) east of Tutuila and shares its warm and wet tropical climate. Tau average rainfall is more than 2,500 (98 in) mm per year and is highest in December. The dry season is June to September, and droughts sometimes occur on the island (Whistler 1992).

CONCEPTUAL ECOLOGICAL MODEL

The landscape ecological conceptual model is useful for communicating and understanding specific processes and issues related to the landscape topic. This conceptual model also provides a basis for identification of potential vital signs, which are a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values, that may be selected for monitoring (Fig 2.). This conceptual model illustrates linkages between the forces of change (drivers) to the affected landscape topics (attributes) and the measures.

In this model, drivers occur independently of one another, but may operate simultaneously, magnifying the effect of associated stressors on the ecosystem. This interaction between stressors and ecosystem responses is indicated in the conceptual model by placing stressors in a single box, which then initiates several categories of ecological effects. The model endpoints are various ecological measures which can be used to indicate ecological effects.

EXTERNAL DRIVERS AND ECOLOGICAL STRESSORS

Major external sources of ecological drivers/stressors in the Pacific Island ecosystems emphasized in this model are divided into two categories (e.g. natural and anthropogenic). They include disturbance regimes, climate, gradients and zones, land use, and demographics. In the landscape conceptual model drivers are represented by blue boxes.

Disturbance Regimes: Within the PACN region, storm events (both tropical cyclones and periods of brief and intense rainfall) and earthquakes can significantly affect multiple ecosystems. Other natural disturbances that occur within PACN parks include stream flooding, tsunami, landslides, volcanic activity, wildfires, seasonal high wave events, coastal erosion, and

drought. Large-scale disturbances significantly interact with soil and water resources and conditions, as well as regional climate. In addition, localized disturbances such as landslides in a single watershed or the noise from boat motors may have profound impacts on organisms in a single area.

Climate: While climate is regarded as a natural resource in Hawaii (Juvik and Juvik 1998), it also has the potential to modify landscapes and is considered an ecosystem driver. As described in the Jenny-Chapin interactive-control model, climate accounts for much of the variation in ecosystem structure, productivity, and biogeochemistry (Chapin et al. 1996). Climate patterns include Central Pacific trade winds and Western Pacific monsoons. Other factors include the El Nino-Southern Oscillation (ENSO) cycle, which strongly influences climate on a three to four-year period and changes in rainfall and temperature patterns across the Pacific. Climate change is predicted to cause increased atmospheric and water temperatures, decreased rainfall, and sea level rise in the PACN region.

Ecological Gradients and Zonation: Ecological gradients and zones are based on the substrate, topography, climate, and vegetation of the landscape. Many factors influence these zones such as climate, windward-leeward orientation (orographic), water regimes, and fires. Changes in gradients and zones impact species composition, which can be measured with detection maps to illustrate cover frequency, distribution and age classes. Fragmentation, degraded water quality, and changes in water quantity can also occur as a result of disturbance regimes causing modification to gradients and zones. These events significantly alter landscapes via erosion or addition to the land. Where pollination syndromes occur detection can be observed by monitoring presence and/or absence, phenology, and seed set. Pollination syndromes are characteristics such as shape, depth, color, and scent, which help predict the pollinator.

Land Use: Land use may be classified as urban, rural, agricultural, or commercial. Contiguous landscapes through partnerships is another important aspect of land use. Partnerships provide a mechanism for both uniform land management and for the introduction of drivers/stressors. Partnerships are driven by anthropogenic inputs such as population, economics, and legal pressures. Land use in the PACN is an especially significant issue, as the islands that comprise the network inherently limit available space and raise awareness of this topic. Alterations in land use and cover may contribute to and be indicative of pollution of water and air resources, fragment habitat, alter movement patterns of wildlife, increase soil erosion, and facilitate the introduction of alien and invasive species.

Demographics: Demographics refers to human populations especially with reference to size and density and distribution. America's population continues to grow but is sometimes so subtle that it goes unnoticed. Ecologists recognize population dynamics as a core process of ecosystems, while land managers and policy makers often fail to associate the increase in population to the health of parks (Kaye 1996). The increase in population leads to a demand and impact on natural resources. Immigrants and citizens alike, harvest plants, animals, fossils and minerals depleting natural resources in parks. Parks also provide recreational areas for people where our natural and cultural resources are preserved. The survival and health of parks ecosystems is reliant on educational programs to articulate sustainable societies guaranteeing sustainability of the national parks.

ECOLOGICAL ATTRIBUTES

The ecological attributes included in the landscape ecological conceptual model consist primarily of the set of vital signs proposed for monitoring landscape issues in the PACN. Vital signs, as used by NPS are "measurable, early warning signals that indicate changes that could impair the long-term health of natural systems". In the model (Figure 2) they are represented by green octagons.

Lightscapes: Lightscapes are essentially driven by land use and refer to the status of the night sky (presence/absence) of light pollution. The alteration of the nocturnal lightscape can be detrimental to wildlife. Low-pressure sodium (narrow spectrum yellow lights), often preferred by the astronomical community, have not been shown to be beneficial across all life forms. Changes in lightscapes can be measured by spatial distribution, temporal frequency and light intensity.

Soundscapes: Soundscape refers to the total ambient acoustic environment, which is made up of both natural and human caused sounds. Human caused sounds are not just the sounds that people themselves produce, such as talking, but also the many varied sounds that attend the presence of people such as autos, aircraft, radios, and pets. Acoustic ecology and research in bio-acoustics is an important tool for defining the health of natural habitats. For the purpose of the landscape ecological conceptual model, Land use is a driver/stressor of a soundscape; thus, the measure is changes in decibel levels.

Viewscapes: Viewscapes are vistas from specified locations which offer scenic views into volcanic craters, lava flows, mountains, native forests, natural geological faults, the Pacific Ocean and volcanic steam vents. Other types of viewscapes include culturally and historically significant vistas. They are driven by both natural and anthropogenic inputs such as climate, land use and disturbance regimes. Ecosystem responses can be detected in changes in air quality and visibility. Other examples of drivers are geologic activity, vegetation growth, forest succession, and degraded air quality, which significantly alter or modify the viewscape.

Visitor and Management Impacts: Visitor and Management Impacts include an increase in the number of people within parks, which is the presence of humans in and of itself and an upsurge in use of quantity of paths and trails. These require stewardship efforts on the part of management and visitors alike. Increased visitation often leads to the removal of objects with natural and cultural significance. They are entirely human induced and can be measured by the changes in cultural resources, erosion and plant cover and overall landscape integrity.

Mangagement Zones and Use Areas: Management Zones and Use Areas are generally marked out into various categories such as the Development, Natural and Historic zones respectively. They are influenced by number demographics of park users and measured by counting visitors and quantifying visitor uses and extent by mapping.

Wilderness: Wilderness, as stated by the Wilderness Act of 1964, is "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain." Wilderness managers require scientific research to understand the character of wilderness ecosystems, the biological and social impacts of human activities on wilderness ecosystems, the role of wilderness in larger social systems, and the impact of different policy and management alternatives. Measures for impacts to wilderness area are related to Limits of Acceptable Change (LAC). LAC refers to management efforts to determine how much change is

acceptable to an area before it adversely impacts the natural resources. LAC runs parallel with demographics, immigration and emigration. Measures are determined by monitoring buffer zones, trail use and visitor counts.

Chemical Information and Odor: Natural chemicals released by animals, plants, and geologic materials are transmitted through the air and water. These chemical odors modify animal behaviors such as mating, migration, feeding, predator avoidance, prey selection, and the establishment of social structures as a response. Land use has the potential to create an increase in chemical odor. Unfortunately, this topic has not received the same attention as soundscapes (due to increases in air tours) and lightscapes (decrease in the dark night sky). Hopefully, as this topic develops, more information will be available to provide park managers information to detect status and trends of resources and impacts from chemicals and odors. Presently, measures for this topic run concurrently with air quality at parks such as HAVO, where there is an increase in sulfur levels.

Culturally Significant Resources: An increase in demographic immigration and emigration along with other drivers such as climate, disturbance regimes and land use would indicate the potential for impacts on culturally significant resources. Measures for this attribute can be detected in quantifying percentage of changes of cultural resources, such as reduction in species (marine & terrestrial). Systematic monitoring of harvested species with collection statistics would apply for this ecological model.

ECOLOGICAL MEASURES

The ecological measures presented in this landscape conceptual model can be used to provide early warning signs of resource conditions and determine ecosystem integrity. Ecological measures are depicted in the model (Figure 2) by parallelograms.

Table 1. Ecological measures of the attributes in the PACN landscape ecological conceptual model

Ecosystem Attribute	Ecological Measures
Water Quality	Turbidity/Nutrients, Light Attentuation, Toxics/Debris
Lightscapes	Spatial distribution, temporal frequency, light intensity
Viewscapes	Air quality, visibility
Soundscapes	Decibel levels
Chemical Information & Odor	Behavioral changes
Visitor Impacts	Increase in invasive species, trail use, changes in plant cover, increased erosion
Wilderness Areas	Buffer zones
Management Zones	Quantifying visitor use and extent, mapping
Culturally Significant Resources	Changes in cultural resources, reduction in species (marine & terrestrial)
Air Quality	Aerosols & gases, changes in visibiltiy
Water Regimes (Quantity)	Fragmentation, erosion/addition of landscape
Species Compostion/Competition	Cover frequency, distribution, age classes
Meteorlogic Patterns	Weather parameters
Pollination Syndromes	Presence/absence, Phenology, Seed Set

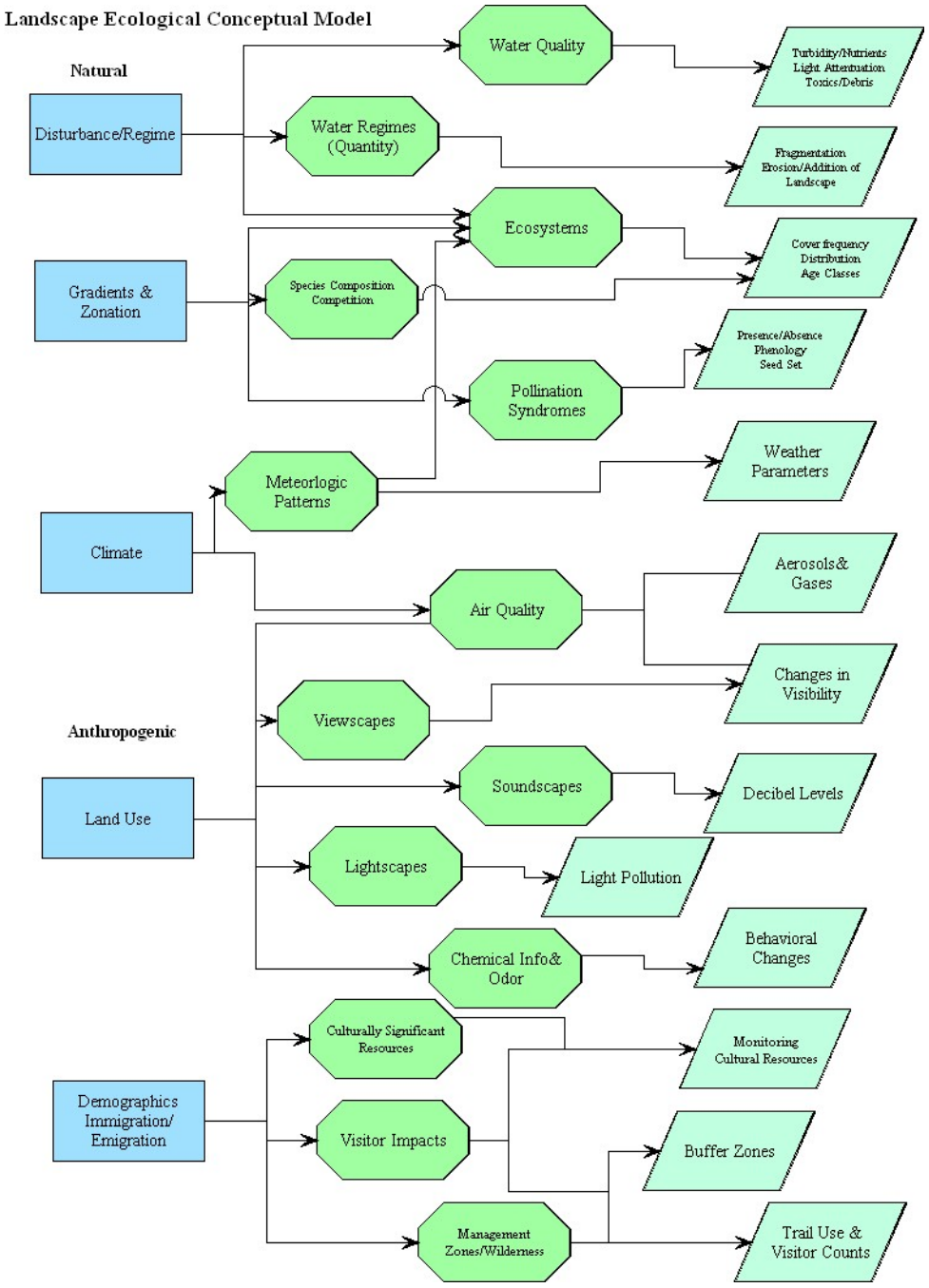

Figure 2. Ecological Landscape Conceptual Model: Symbols represent drivers (rectangles), landscape ecosystem attributes (octagons), and ecological measures (parallelograms)

PARK AND NETWORK-WIDE ISSUES

LAND USE

Land Use refers to the way land is developed and used in terms of the kinds of anthropogenic activities that occur (e.g., agriculture, residential areas, and industrial areas).

All of the parks in Hawaii are owned by the Federal Government with the exception of KALA where some of the land is owned by the Department of Health, Hawaiian Homes and the Federal Government.

In Guam, the government seeks to promote an orderly land use pattern and provide for increased development when appropriate. The land at WAPA is primarily owned by NPS with a few private inholdings. Submerged lands are managed by NPS with 2/3 of it owned by the territory of Guam and the other 1/3 is unconfirmed but believed to be federally owned.

AMME has much more complicated land ownership with ownership belonging to the commonwealth, leased to the military and then given to the NPS. NPS has management jurisdiction over the land but CNMI has the overall authority and sometimes exercises that power.

Some land use issues for American Samoa revolve around the lease agreement in which the NPS has authority to care for only a small part of the natural resources. Cooperating with American Samoa Government agencies, the village councils, and others to assure long term feasibility of sufficient habitat for native species, such as flying foxes or fruit doves, which are presumed to be strong interactors in the ecosystem has been a high priority for park management.

Within PACN parks

Traditional use areas (special & historical use areas): The ability to obtain past and current land use data to accurately identify special and historical land use areas is a major concern for some if not all parks subsumed in the PACN to maintain and protect historic land use practices. Preserving historical use areas and conserving natural and cultural resources within the parks without limiting access to native peoples has been an issue for park management. This requires the balancing of management policies with traditional use of lands.

Monitoring special use areas where subsistence farming is occurring or reoccurring to track long term trends while obtaining a natural history of the area is an important aspect for all PACN parks (e.g. NPSA) (Fig 3.). On the island of Tutuila, at NPSA, subsistence agriculture has been reoccurring where the land has been fallow for a number of years. Due to inholdings within park boundaries, it is important for park managers to monitor land use for early detection of resource degradation.

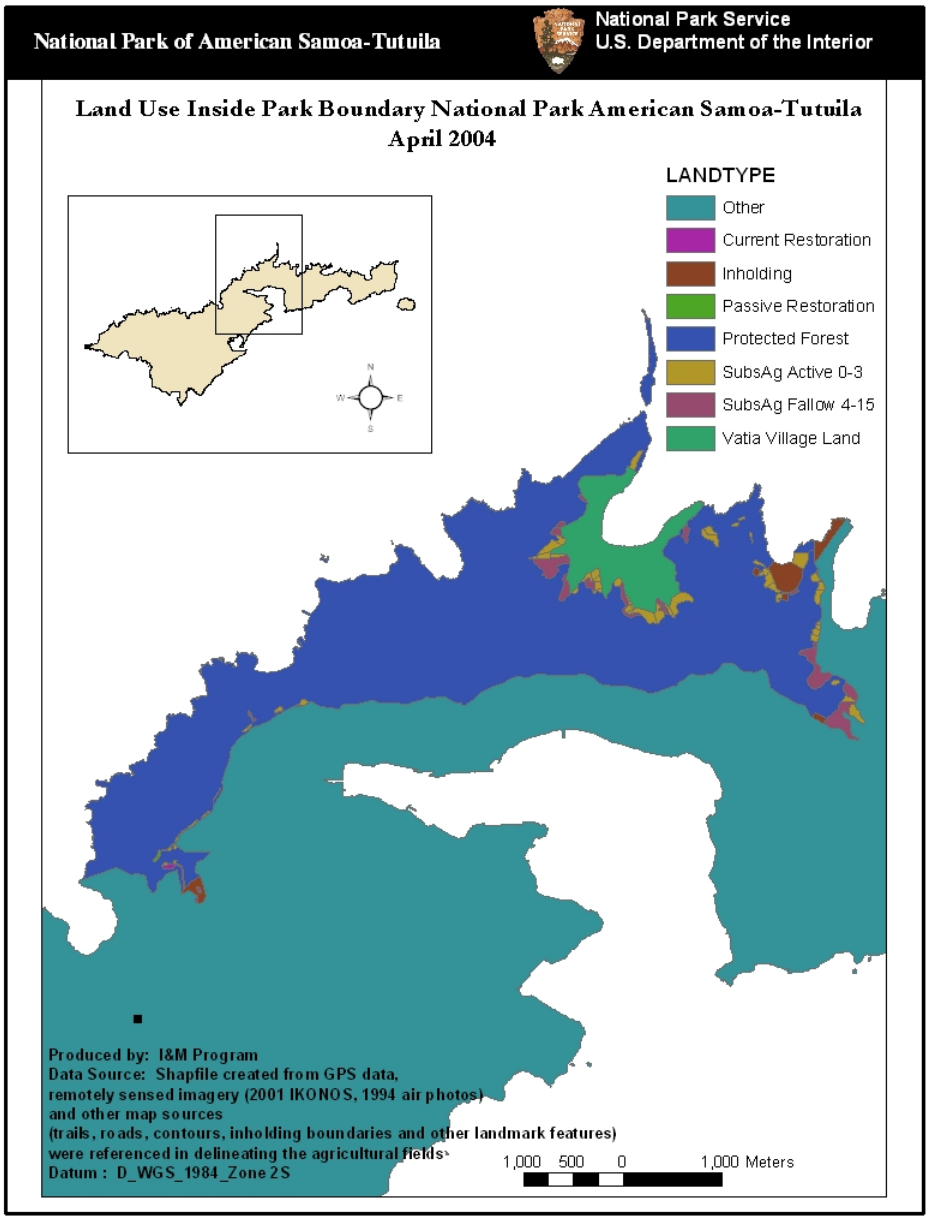

Figure 3. Land Use Map; National Park of American Samoa-Tutuila

Adjacent land use pressures on parks

The Kalaupapa Airport is federally subsidized and admininstered by the Hawaii Department of Transportation (DOT). The airport occupies 55 acres on the northern peninsula of Molokai, which is two miles north of the Kalaupapa community living within the park. Facilities at the airport are minimal including a single runway, small passenger terminal and airport support area. There are no planned improvements for the airport to abide by the wishes of the community and lessen any disturbance for the surrounding National Historical Park.

Adjacent land use changes surrounding KAHO have significant impacts and threaten park resources. Increased pressure on potable water due to urban development, housing, small boat harbor expansion, oil and fuel line development as well as increased traffic along major highways will adversely affect the aquatic water system and park resources.

Pressure from adjacent land use has also been inflicted on AMME, as the nearby town of Garapan has experienced increased development. Litter, trampling, and illegal harvest of vegetation are some of the known stressors from development.

Proposed new housing developments upslope of PUHO will impact ground water resources from septic leaching as the lands become urbanized. Increased development will also result in the introduction and infestation of invasive species, especially predatory mammals that directly threaten native species.

The expansion and development of "Science City" a multi-institutional collection of facilities comprised of observatories and antennas, located on state land just southwest of the summit of HALE is aesthetically and ecologically degrading to the wilderness and spiritual attributes of the park.

The HAVO helipad an FAA approved emergency landing site located behind the rainshed is used by the Park Service for resource management efforts, emergency purposes and sometimes in conjunction with Drug Enforcement Agency efforts. Noise generated from helicopters has the potential to be disruptive to visitor experience.

As mentioned previously, the government of Guam practice to promote development has lead to an upsurge in development in the watersheds above both the Asan and Agat Beach unit. Construction activities have led to an increase in erosion as the local government is not consistent in enforcing anti-erosion regulations. Growth is also seen along the coast, with several buildings adjacent to park waters, built out on the seaward edge on seawalls.

Changes in Land Use/Distribution and Abundance of Invasive Species

The decline in agricultural and ranching practices has led to the increased infestation of (*Miconia calvescens*) due to the nature of the species characteristic to occupy openforested areas. Access seems to be the major issue for the eradication of *Miconia* in densely populated forested areas. *Miconia* is an invader of light gaps and provides a forest understory incompatible with fostering a native ecosystem. In addition, feral ungulates, particularly pigs, are responsible for increased infestation of avian disease by creating habitat for mosquitos, which carry avian malaria and pox, in native forests. They also play a role in the dispersal of alien plant seeds which have significant impacts on native forests.

Myrica fiya successfully invades rain forested areas of high elevations (sub-montane) where ranching activities commonly occur. The decline in ranching activities has led to a higher dispersal of the *Myrica fiya* tree. Because access to these landscapes is extremely limited, physical removal of the tree is difficult due to the inability to use machinery in these areas.

The demise of the sheep industry has had a significant impact on the spread and invasion of Gorse, which had been introduced for foraging by the sheep. The noxious weed is nearly uncontrollable except for a biological control agent (mite predator) used to damage the plants, which takes months to effectively kill the plants.

Water quality

Land use change surrounding natural areas can have impacts on water quality especially in situations like Kaloko-Honokohau where the natural area has become surrounded by a commercial and light industrial use area. Marine ecosystems are affected by increased runoff from upslope development. Additionally, water quality in Guam is greatly affected and aquatic resources are impacted from traditional burning. WAPA has a relatively high frequency of fire. Fires are intentional, resulting from agricultural practice, the facilitation of pig and deer hunting, and arson. Hence, traditional burning results in an increase in sedimentation impacting water resources.

Wildlife movement and foraging

Park management restricts human activity at the Ainahou Ranch House during breeding season of the Hawaiian endangered goose (*Nosochen sandvicensis*, Nene). In addition, pasturelands at Ainahou Ranch are managed by NPS to promote foraging of the Nene. There appears to be more protein in the grass when it is shorter providing supplementary nutrients for the endangered species. This is especially important during breeding season and during the first year for goslings.

LIGHTSCAPES

Wildlife impacts

Birds: Nocturnal birds are at risk from light pollution because they use the moon and stars to guide their migration patterns. They are susceptible to collisions with night lit towers across North America. Sea birds such as the Petrels feed offshore and are fatally drawn to high intensity lamp lights from fisherman, lighthouses and offshore drilling platforms.

Turtles: Due to the lack of lighting ordinances on Maui, the critically endangered hawksbill turtle habitats are threatened from light pollution. Floodlights from shoreline homes have negative impacts on sea turtles, which are disoriented by the lights and sometimes end up on land instead of heading back into the ocean. When hatchlings emerge they go to the lights instead of the ocean, jeopardizing their survival. This also happened at the HAVO Hawksbill Monitoring Project located at Punaluu Beach Park in Kau. Lights from a parking lot and residential area had to be lowered and one even turned off during nesting season by the County of Hawaii.

Cultural

Night sky viewing & brightness: Night sky viewing has been termed “The Ultimate Cultural Resource”. The loss of remaining night sky due to light pollution continues to affect humans who value this once significant resource.

Celestial navigation: The recalling of cultural heritages in recent times has empowered indigenous peoples of the Pacific Islands to resurrect the art of celestial navigation, which uses the stars to navigate ocean voyages. The Hokulea project, which began in the 1970s, is an example of how the Native Hawaiians demonstrated their traditional abilities of navigation, and exploration by canoe voyage to Tahiti and other South Pacific expeditions. Lack of shielding for outdoor lighting is increasing sky brightness which in turn reduces the contrast between the

background and fainter stars making them invisible to the eye; Therefore greatly reducing the ability to apply the traditional art of celestial navigation

Scientific

Astronomy: Astronomical light pollution is when stars and other celestial bodies are washed out by light that is either directed or reflected upward (Longcore & Rich 2004). While shielded lights significantly reduce the amount of light pollution, they still cause ecological light pollution.

Light pollution on Maui creates adverse conditions for astronomical research. The primary source of light pollution is the "cobra head" street lights that shine 30% of light into the night sky instead of on the street. Athletic field lights and partially shielded lighting in parking areas also contribute to the light pollution as well.

SOUNDSCAPES

Native/natural sounds

Park management includes the goal of preserving the natural sounds and taking action to prevent and minimize all noise which affects the natural soundscape. Managers enforce regulations, monitor human activities and use mitigation to protect the natural soundscape. Desired conditions achieved by management are assessed in the EA/EIS process.

Focal species (birds/bats, diurnal/nocturnal): Impacts in reproduction can be caused due to hearing loss in mating calls. High stress levels result in an increase of susceptibility to disease, learning disabilities and weight loss. Loss of territory and migration also affect endangered species.

Nosochen sandvicensis commonly known as Nene, have been observed while feeding when helicopters fly overhead at the Ainahou Ranch (Knight pers.comm.). The endangered Hawaiian goose (Nene) has reportedly been seen to lay flat on the ground during air tours in the park (Knight pers. comm.). The stress they encounter from air tours has been evident in the time it takes them, (several hours), to resume their normal feeding activities. Anecdotal information has been provided by NPS for the purpose of this report.

Pre & post Fire: Lava ignited fires at HAVO have resulted in the increased use of helicopters for water drops. These operations are carefully monitored by management to ensure the safety of visitors and personnel. The noise during these operations is unavoidable for obvious reasons.

Accessible (road noise)/inaccessible (wilderness) areas: Road noise is inevitable due to the component of wilderness areas within the development, special use and transportation zone. The objective is to keep the human induced noise levels as low as possible to reduce significant adverse impacts. Buffer zones may be enforced to reduce impacts on wilderness areas.

Biologic component to acoustic monitoring: The National Park service will restore degraded soundscapes to the natural condition wherever possible. NPS will take action to prevent or minimize all noise that, through frequency, magnitude, or duration, adversely affects the natural soundscape or other park resources or values.

Wilderness solitude-quiet as a resource value: In general, along trail corridors that traverse through wilderness areas some human induced noise is unavoidable. But the main goal is for the visitor to experience the natural sounds of the environment. In larger landscapes, such as backcountry areas, the objective is to have no intrusion from human induced noise to experience the entirety of the wilderness.

Exotic Species sounds

Noise from the highly noxious and invasive coqui frog (*Eleutherodactylus coqui)* is a major impending threat on the native ecosystems in Hawaii. Coqui frogs have been found in isolated locations at HAVO. The frogs have been eradicated by the NPS in efforts to preserve the native ecosystem. The loud continuous chirp of the male frog exceeds 90 decibels and is most notable in the night but the frogs can also be heard on cloudy overcast days. Coqui frogs consume high levels of insects and their mating call has the potential to interfere with native bird communication. Furthermore, the coqui frog has established populations on adjacent lands near PUHO, which has been documented in a recent herpetological survey (Bazzano 2004). Bazzano reports the Upland Garden at PUHO is most at risk from the coqui due to its close proximity of known populations as well as wetter conditions, which is conducive to amphibian inhabitance. Removal of the exotic species creates favorable conditions for the increase in native populations due to the ability to distinguish between mating calls, and sustainability of food sources.

Anthropogenic Noise

Aircraft, boats, vehicles, people (recreational noise): Noise from aircraft is the primary source of human induced noise. Air tour flights have been increasing over the years. Although the SRAR-71 requires Air Tour Operators (ATO) to maintain a Above Ground Level (AGL) of 1,500', the FAA has granted a number of waivers to lower the (AGL) to 500'.

Park operations: As stated in the management plan, park operations are to be limited to those necessary for achieving park purposes, and maintaining the health and safety of employees and visitors. NPS does try to limit the amount of noise when they perform various projects.

Interruption/stress of wildlife communication: Noise can adversely impact animal communication by disrupting territory establishment, courtship, nurturing, predation, avoiding predators, migration, and foraging functions. Physiological effects can range from excessive alertness, health affecting stress, decrease in lactation of nursing females, and changes in the metabolism and hormone balances (EPA 1971). Indirect effects can include injury, abandonment of or damage to young, and avoidance or abandonment of habitat. Where species are already threatened, habitat abandonment could be detrimental to existing populations.

Marine sounds: Marine sounds come from two identifiable sources: (1) natural ambient noise from wind, waves, earthquakes, volcanic activity, rain, movement or breaking of sea ice, animal activity and thermal noise; (2) noise from human activity (Dotinga and Elferink 2000).

Fauna: Effects of noise on marine life is dependent on the species, their sensitivity level and the environment conditions in the area where noise is present . Baseline conditions and the activities of the particular species at the time of disturbance are variables that determine changes in species behavior or habitat. Most of the documented impacts from noise have been on larger marine mammals such as whales, dolphins and porpoises. Some of the effects from noise on marine

species include interruption of resting, feeding, or mating. In the case of cetaceans, noise can affect respiration, surfacing, or diving (Dotinga & Elferink 2000).

Pollution: Anthropogenic activity including vessel activity, seismic surveys, sonars, oil and gas drilling, dredging, construction and military activities are the main sources of noise pollution in the marine environment. Vessel movement is mainly caused from shipping activities in the marine environment. Noise produced by the vessel is mainly caused by the propellers but the size of the ship, its load, speed, type of engine, and mode of operation are other factors contributing to the amount of noise. Sonar noise varies widely in intensity and frequency. They are used for measuring depth, bottom scanning, and detection of fish, and submarines. Military sonars are known to be very powerful and produce loud noise. Dredging also contributes to noise and can produce strong and continuous noise at low frequencies. Similarly, construction and tunnel boring cause varying levels of noise and are mainly low frequency. These activities take place primarily in coastal areas where the construction of artificial islands are occurring. Seismic surveys use airgun arrays and similar devices to locate geologic structures and study geologic processes. While these activities are short in duration, the noise pulses are high in decibel level. These processes disrupt marine life adversely affecting potential population, behavior, and migration patterns.

Event related

Prescribed burns are used by fire managers as a tool to re-establish ecological integrity. These activities require the use of helicopters to detect and evaluate fires for further action. At HAVO, helicopters are used for reconnaissance of lava flow activity and accessing fire potential. Helicopters are also used during fires to deliver water drops to fire lines, manage personnel and monitor fire activity.

CHEMICAL INFO & ODOR

While emissions of aerosols and gasses at HAVO are a natural geologic process, they are often a health hazard and impact visitor experience, employees, interpretation, and visibility. This process can also hinder wildlife from tracking scents in an effort to forage and reproduce.

Alien vegetation, such as the kahili ginger, is another issue at HAVO. This highly invasive plant has a strong aroma and is able to impede the smell of native *ohia.*.

The septic system located at Spencer Beach Park, adjacent to PUHE is managed by the County of Hawaii. The septic has a tendency to emit a noxious odor upon high tide conditions. This situation negatively impacts visitor experience as well as water quality for both ALKA and PUHE.

The stench from tuna canneries located near NPSA is known to penetrate into park boundaries and have similar effects to wildlife and visitor experience. Visitors may not be able to experience the natural processes occurring such as flowering plants and naturally fresh air.

Prior to 2001, the Agat Sewage Treatment Facility dumped effluent directly within the Agat unit at WAPA. This facility has since closed and effluent is now released through a deepwater outfall to the north of the Agat unit. In addition, chemical contaminants from a ammunition dump off Camel Rock, with a reportedly 64 tons of unexploded munitions is within the park's boundary. Metals from relic equipment can have significant ecological effects on the community.

VIEWSHEDS & SCENERY

Protection of designated areas

Protecting viewsheds and scenic vistas are essential for many natural areas. Park management must identify areas in need of visibility monitoring to determine air quality conditions in conjunction with the Interagency Monitoring of Protected Visual Environments and Clean Air Act. Visibility has the potential to impact scenic vistas in PACN parks due to volcanic activity in parks like HAVO. The parks must determine if changes in the landscape have occurred by implementing a monitoring plan which is conducive with improving viewshed and scenic vistas. Exotic plant species also has the potential to negatively impact scenic vistas and hinder the scenery of the natural landscape.

Undesignated areas

Roadside clearing for vistas: Clearing commonly visited areas can help in managing traffic flow along roadways and corridors as well as provide a safe place to pull off the shoulder of roadways. Park officials at HAVO have seen an increase in the number of pullouts, where visitors will stop to take a picture. Assessing the site to ensure there is no cultural, historical or architectural significance within a locale is useful to mitigate impacts on resources. Identifying additional locations is useful for PACN parks to track long term status and trends of the area.

The Fonte Plateau Unit located at WAPA is a proposed overlook area containing a tunnel with historic significance from WWII and a native plant community on the slopes below the potential overlook. There is a limestone forested area with native vegetation extending down the north facing slope.

External land use changes

Modification of landscapes usually occurs with a change in the conditions such as vegetation where the character of a landscape change occurs when there is volcanic activity, catastrophic fires, tornadoes or hurricanes. Other types of land use change such as development, poor local zoning regulations, and numerous cell phone tower proposals degrade scenic integrity. Most of the parks in the pacific have experienced some level of development that has impacted the viewsheds. The smaller parks are most at risk due to their relatively small size.

PUHO and HAVO are impacted by volcanic smog conditions from Kilauea Volcano degrading and modifying the aesthetic viewscape.

The proposed expansion of the small boat harbor (Honokohau Harbor) adjacent to the park, along with increased development has impacted the historical viewscape at KAHO.

Vegetation changes (internal & external) either obstructing or modifying area being viewed

Vegetation management to preserve a completely open view (e.g. Kilauea Iki Crater) is necessary to maintain the historical view. As stated in The National Park Service Management Policies Chapter 4.4.2, Management of Native Plants and Animals, parks should permit the

management and removal of native and exotic plants, to protect specific cultural resources of parks (NPS Management Policies) (HVNP Viewshed Inventory and Assessment).

Non-native vegetation at PUHE has obstructed the historical open view of the John Young homestead. Overgrown kiawe trees have adversely impacted the viewscape from the parks historical focal point, which is the historical open ocean approach to the coastline. The native Hawaiians would approach the site by canoe, which offered the view of the landscape from the coastline.

Inventories and Assessment

Some of the main goals of a viewshed inventory and assessment are to identify and inventory historic and proposed viewsheds of outstanding beauty and scenic quality, assess vegetation management actions necessary to reestablish historic viewsheds and conserve and maintain existing and proposed viewshed quality and character. The HAVO Viewshed Inventory and Assessment is designed to preserve the character of historic views by creating maintenance guidelines for each site including an existing photo, Global Positioning System (GPS) locations, and maintenance recommendations.

VISITOR & MANAGEMENT IMPACTS:

Disturbance of species/habitats

In general, national parks in the Pacific continue to experience an increase in visitation. Impacts from visitation can be devastating to natural resources within the parks. NPSA is faced with the possibility of diminishing resources due to traditional subsistence practices inside the park. Park management is confronted with the task of reaching agreements with village councils in determining rules regarding subsistence uses. There is also a need of to assess the relationship of subsistence users with the land and water both past and present in an effort to track long term trends occurring within the national park.

Parks like the ALKA, where public access is easily accessible along the coast and park interpretation and enforcement is not yet established in many areas, face multiple impacts from visitors. The trail is subject to erosion from foot traffic, motorized vehicles, and construction activities. These activities can also attribute to loss of habitat for native species where nesting and foraging is occurring along the trail. Other impacts from visitors include waste disposal, trampling of native vegetation and spread of alien species from unclean footwear.

While park managers are tasked with managing park resources "*unimpaired for the enjoyment of future generations*", their efforts can sometimes cause more harm than good. For example, HAVO resource management has been involved in fencing areas to control ungulate activity. These efforts have been found to negatively impact the native dark rumped petrels that nest on the slopes of Mauna Loa and forage offshore. Several of the birds have been found dead along the fenceline during their attempts to engage in routine foraging activities. Resource management has since been using a 6 foot fence in an effort to minimize any further impacts on the species.

PUHO experiences high levels of erosion along the beach and trails from high surf events accelerated by foot traffic. It is the practice of management to put down tarps over the cultural

layers at the shoreline and then place crushed coral as a fill along the routes. The fill is contributing to turbitity and sedimentation of intertidal and coastal resources.

Removal of objects

The basic management strategy of the National Park Service is, *in situ*, to leave objects undisturbed. Despite increased efforts by park management to educate visitors on natural resources, visitors continue to remove objects as souvenirs. Although the PACN share natural resource characteristics, individual parks have their own unique resources. Parks such as WAPA, NPSA, & KAHO continue to experience impacts from the daily collection of sealife from reefs and reef flats within the park. At WAPA and NPSA, collection activities are mainly in the form of subsistence and cultural practices where fishing and agriculture are common inside park boundaries. Collection of freshwater shrimp (*Halocaridina rubra*) commonly known as opae-ula, is an ongoing issue along the west Hawaii coastline. The red shrimp is collected for human consumption, aquarium fish and sold as live food for other aquarium fish. The impacts of this activity are unknown but are presumed to be deleterious to the outstanding natural values the park was created to conserve.

PUHO staff continues to notice evidence of missing archeological artifacts from caves and cultural sites. Large carved stones have turned up missing and heiau walls have been vandalized. The park apparently does not have adequate law enforcement to monitor areas where theft and vandalism is taking place. Lack of law enforcement in areas where theft and vandalism is occurring, is due to understaffing and lack of funding.

Resource components important to visitor experience

Ironically, some of the same significant resources visitors come to experience are adversely affected by them. For instance, the heiaus at PUHE are the primary attraction for visitors and they continue to degrade them by trespassing. These heiaus built without mortar are fragile and an integral park component. Likewise, the fishponds at KAHO are the principal focus for visitor attraction and experience, but they are subject to contamination by visitor use.

Likewise, AMME's primary purpose is to provide recreation and interpretation of historical accounts of World War II and its relationship to the Pacific Theater. The park is used for celebrations by citizens and tourists alike. The most significant impact from visitation is waste, which contributes to feral animals threatening the native ecosystem.

Road Corridors

Herbicidal roadside spraying is necessary to control the spread of invasive plant species in terrestrial areas. Resource management crews at HAVO commonly use a mixture of Round-Up in a localized effort to combat and control exotic plant species. An example of this has been documented in the control efforts of mullein, a biennial herb naturalized in temperate areas on the island of Hawaii. Mullein has been located along roadsides of the Mauna Loa road beginning in the 1970s but control efforts did not start until 1989 (Loh et al. 2000). These practices are necessary not only with mullein but with other invasive species posing a threat the native ecosystem.

NPSA is faced with a litter problem near roadways and along park boundaries. However, in the remote areas of the park there is little trash due to minimal visitors hiking in the park.

MANAGEMENT ZONES & USE AREAS

Like most of the parks in the PACN, HAVO is comprised of four different management zones (1) The Natural zone (2) Historic zone (3) Development Zone (4) Special Use and Transportation Zone. The natural zones primary focus is on conservation of natural resources and its processes. The historic zone includes a variety of separate sites within the park where early human habitations are found. The development zone is comprised of administrative, residential and visitor facilities. The special use zone includes trails used by park employees to access administrative facilities and visitors to access attractions. This zone would also include Kilauea Military Camp located at the caldera site. Although the trails traverse through the natural zone they are best managed under the Special Use and Transportation zone.

WILDERNESS:

Management actions of appropriate intensity/manipulation

All areas designated as wilderness are restricted in the use of motorized equipment and mechanical transport except in the case of emergency. In the case of HALE where 27,719 acres is designated as wilderness, access is permitted and limited to trails only. Fires are permitted in designated fire places and pets are highly restricted. At HAVO fencing has been and continues to be instrumental to limit feral animals from entering the area. Wildfires are controlled to prevent the loss of wilderness lands, life and property. Population control of predators (i.e.rats, mongoose) is encouraged with trapping to control and eliminate alien animal species. Roads, timber harvesting, water development projects and mining are restricted from wilderness areas to preserve the wilderness values. Grazing and hunting is also restricted except where permitted.

Encroachment of boundaries

Boundaries for backcountry areas can be jeopardized when the buffer zone surrounding wilderness regions are infringed upon by development. Although there has been some issues regarding the recommended buffer, (200 meters wide), agencies have adopted the informal policy of creating *de facto* buffers outside of wilderness to protect wilderness (Kelson 1998). Over the last 20 years proposed development just outside of park boundaries posed direct threats to wilderness at HAVO. Monitoring these areas over a period of time can reduce the amount of loss in wilderness areas and quality of wilderness lands.

Limits of Acceptable Change (LAC)

Limits of Acceptable Change (LAC) is a system that was developed in response to the growing number of visitor use in wilderness protected areas. LAC is an attempt to define and implement recreational carrying capacity. The carrying capacity model can be used by managers as a tool to determine how much change is acceptable without affecting resources. Implementation of monitoring programs is essential to protecting resources for natural areas. The methodology for establishing LAC has been studied over a number of years to address problems associated with

recreational use in natural areas. National Parks often refer to LAC as Visitor Experience and Resource Protection (VERP) (National Park Service 1993). In 1992, annual visitation for HALE was over 800,000 for the summit district. Although park management has limited visitor use to few areas in the summit area, park facilities are often exceeded and impacts to fragile ecosystems are greatly increased.

Increasing human activity

In general, wilderness areas have seen a tremendous increase in recreational activities in the past 40 years (Cole & Landres 1996). Wilderness areas are becoming more frequented by visitors seeking solitude, and scientists conducting research from outside laboratories. At HAVO, backcountry use is found frequently along the trail leading to Halape as well as visitors viewing lava flows. Some of the issues for these areas are lack of fresh water and shade along the coastline and an increase in trash in campground areas, which can lead to infestation of rats and other predatory animals that adversely affect natural resources. Backcountry use is regulated and monitored by law enforcement rangers to mitigate potential impacts to fragile ecosystems. Hence, there is still a large number of reports at HAVO on illegal activity such fires in camping areas, trash left behind, and numerous boats sighted off the coast fishing.

Backcountry areas at HALE experience significant impacts from increased visitors to the area. The high elevation "aeolian zone" is most susceptible to visitor use due to the spectacular scenic vistas of the crater and campground sites. Visitors are drawn to these sites for the natural resource and cultural values they offer. Cinder compaction is a direct physical impact to the landscape threatening the unique endemic fauna on Haleakala. Local impacts at campground sites range from leaving food and garbage to inappropriate use of fire rings using native trees and shrubs for fire wood resulting in the sprouting of alien fruit tree in cores and infestation of roaches and rodents.

Table 2. Comparing Network-wide issues by Parks

	WAPA	AMME	NPSA	USAR	KALA	HALE	ALKA	PUHE	KAHO	PUHO	HAVO
Land Use	x	x	x	x	x	x	x	x	x	x	x
Lightscape		x			x	x	x	x	x		
Soundscape	x		x		x	x	x	x	x		x
Chemical Info&Odor			x	x		x		x			x
Viewsheds & Scenery	x		x		x	x	x	x	x		x
Visitor & Management Impacts	x		x			x	x	x	x	x	x
Wilderness			?		?	x					x
Cultural Resources	x	x	x	x	x	x	x	x	x	x	x

CRITICAL RESOURCES

WAPA

Ecological gradients: Native savannah grasslands can still be found on the slopes of the Agat and Asan units in Guam. They consist of native swordgrass with scattered iron wood trees. The savannah area, dominated by grasses, low shrubs, and small trees, is threatened by large and frequent fires that are intentionally set. In the past, fire was used to manage the landscape and the invasive tangentangen that was used by the Navy during WWII as a ground cover to decrease erosion. Savannah areas are highly susceptible to erosion and encroachment of the exotic mission grass. It is unknown if wildfires will contribute to the conversion of the savannah to the exotic mission grass.

Some limestone forest can be found in the beach area, river valleys, and Fonte Plateau slopes of the Asan Unit as well as the slopes of the Mt Chachao Unit and the coastal islands and slopes of the Agat Unit. These forests occur on exposed limestone with a typical mosaic of intergraded subtype communities resulting from local dominance of one or two typical species (Raulerson 1979). Mt. Lamlam, the highest point on Guam, possesses a well-developed limestone forest. Due to its inaccessibility, this limestone forest has been able to escape degradation and remains an intact ecosystem.

Soundscapes: The terrestrial soundscape has been altered with the loss of bird sounds as the result of predation by the brown tree snake and habitat loss. Natural marine soundscapes have also been severely altered by military, commercial, recreational and tourism related activities. Apra Harbor, the islands primary commercial and military harbor, sits between the Asan and Agat Units. Large vessel traffic, including military submarine traffic, is common but restricted to offshore waters.

Lightscapes: There is a considerable amount of light pollution at WAPA and some is generated by the park. WAPA is very much an urban park and suffers from this problem. But the impacts are minimal compared to surrounding urban areas.

Management Zones: WAPA consist of the historic, natural and development zones. The historic zone consist of land and water areas necessary to preserve the integrity of individual sites, features, and structures, major battle areas, beach and offshore areas surrounding the invasion beachheads. The natural zone provides protection of natural resources. The development zone contains areas of concentrated park development. These areas have been altered subsequent to WWII and do not contain significant historic or natural resources.

Culturally Significant Resources: Most of the culturally significant resources linked to biological resources at the War in the Pacific are terrestrial and marine species. Due to cultural practices such as hunting, fishing, and collecting of plants for food and medicinal purposes, natural resources are subjected to intense impacts. Increased fires in upslope savanna lands have been a particular issue creating sedimentation in stream and rivers, which in turn affects freshwater shrimp and other species as well as plants along the river banks. In addition, the Pacific Fruit Bats (*Pteropus tokudae*), have a cultural significance to the Chammoro people of Guam. The Mariana fruit bat has been favored as a “delicacy” among the Chamoros (Sheeline 1991). Hence, the decline in the population of *Pteropus* has been attributed to hunting and poaching as well as an increase in the market demands for this species.

AMME

Lightscapes: Light pollution is more serious for AMME due to the lighted walkway that runs along the beach. Sea turtles have been known to pull out on the beaches but have never nested.

Ecological gradients: The 30 acre wetland containing mudflats, mangroves, and marshes is a significant resource in the Northern Mariana Islands. It is critical habitat for native bird species such as the Nightingale Reed Warbler. Mangroves provide food and shelter for fish, and they are also useful in the protection of coral reefs as they filter out sedimentation. The Amme mangrove wetland has approxiamately 200 species of plants and animals, including two endangered species of birds, the nightingale reed-warbler (*Acrocephalus luscinia*) and the Mariana common moorhen (*Gallinula chloropus guami*), and the SOC humped tree snail (*Partula gibba*).

Management Zones: Management zones for AMME consist of the development, natural and marine zones respectively. The development zone is those areas where intensive development has taken place such as picnic facilities, comfort stations, access roads, parking, trails, sports complexes, cultural center, historic center, administrative facility, community plaza and docking facilities. The natural zone is composed of the near pristine wetland and mangrove communities providing habitat for native species. Although the park does not include marine resources, the marine zone has been proposed to include a 100 meter width along the park shoreline.

Viewscapes: Scenic views from the man-made peninsula and the Micro beach area provide views across the broad lagoon to Managaha Island as well as inland to the high hills forming the center of the island.

Culturally Significant Resources: Night sky is a culturally significant feature for American Memorial Historical Park. Traditionally, the park beaches were used by the ancient Chammoros as a teaching beach for navigators, because it is one of the few spots on the islands where ¾ of the sky can be seen to the horizon. This resource has been sacrificed by the lighted walkway installed along the beach.

NPSA

Management Zones: Management zones for NPSA overlay between Natural and Cultural zones. Therefore reflect both natural and cultural resource value. There is a subzone within the natural/cultural zone designed for strict protection as Protected Natural Areas because of their unusual fragility, scarcity, or ecological significance. Within this zone traditional gathering of plants for medicinal and other cultural purposes is permitted. Marine areas are included in the natural zone and ecological carrying capacity concepts are being used to ensure the protection of the natural resources from subsistence reef fishing and gathering. In the unit of Tutuila, a proposed park development will occur along the existing paved road leading to the village of Vatia and the top of Mt. Alava surrounding the upper aerial tramway tower. A visitor use facility is also proposed for this area. The Tau unit will include a ranger station and visitor use facilities near Saua. This proposed development probably won't commence for ten years due to a lack of funding. Proposed developments on the Ofu Unit are to be minimal with little effect on natural processes and cultural resources.

Viewscapes: NPSA has many spectacular scenic vistas such as Pago Pago Harbor, the Mt. Alava-Maugaloa ridge, and Mt. Pioa. Proposed development such as upgrading the existing pavilion located a short distance from the tramway's upper terminus on Mt. Alava will improve

views of the harbor below. Furthermore, the development of a new tramway system designed to bring large numbers of visitors into the Tutuila unit will allow visitors to experience the prime views without constructing new roads. There are also many other proposed overlooks to be installed along the existing unpaved service road leading up to the TV transmitters atop Mt. Alava. Again, a lack of funding for proposed development will delay this project to a future date. Unlike Tutuila, Tau and Ofu are much less urbanized and populated. Ofu consist of pristine white sandy beaches interlaced with lava rocks. The viewcape from the coral reef has a backdrop of the imposing Tumu Mountain. Tau home of Lata Mountain, the tallest peak in American Samoa, also has a magnificent view of the rocky, volcanic coast.

Culturally Significant Resources: (ethnobotanically significant plants-effects of use/disuse over time): Extensive baseline surveys along with an ethnographic overview and assessment have been conducted for park purposes. These surveys assist park management in understanding ancient Samoan plant lore when making important management decision that directly affect Samoan culture. Plant uses generally fall into various categories such as crops and wild plants used for food, plants used for plaiting and clothes making, herbal medicines, timber used for building boats and houses, fashioning tools, artifacts, dyes, personal adornment, ornamentals, and fish poisons (Whistler 2000).

Table 3. List of plant uses; American Samoa (Thaman 1990 & Whistler 2000)

Mats	Decoration	Toys
Clothing	Ornaments	Fishing gear
Sails	Perfumes/scents	Floats
Hats	Toilet paper	Tools
Baskets	Abortifacients	Weapons/hunting
Cordage	Weed control	Insect repellent
Timber	Traps (pig/fish)	Wrappers
Canoes/boats	Soil improvement	Embalming corpses
Artifacts	Totems	Preservatives
Fuel	Switches	Containers
Fire-making	Masticants	Brushes
Torches/lamps	Boundary markers	Dyes
Staple foods	Deodorant	Glues/adhesives
Famine foods	Insulation	Caulking
Spices/seasoning	Recreation	Poisons
Teas	Toothbrushes	Aphrodisiacs
Drugs/medicines	Cages/roosts	Fertility control

Wild/animal food	Commercial products	Abrasives
Soap/shampoo	Supplementary food	Meat tenderizers
Magio-religious	Musical instruments	Shade
Brooms	Fans	

Currently, taro patches are being cultivated inside the park for subsistence uses while some land used for this type of cultivation remains fallow to restore soil nutrients and to rejuvenate the land (Fig 3.). Bananas and breadfruit continue to grow when the taro crops go fallow. Most of the cultivated lands have been abandoned by villagers in an effort to pursue higher education and jobs in Hawaii and the U.S. mainland. The Botanical and Ethnobotanical Inventories report states there are still many cultivated species scattered throughout the Park (Ragone & Lorence 2003).

Traditional plant uses are a way to acknowledge and preserve a culture. These practices remain a primary component in Samoan culture, even though traditional plant lore has declined over the years due to the onslaught of western culture (Whistler 2000). Some villagers still perform a variety of cultural practices using traditional plants such as making rope from coconut husks and fishing traps from roots found on native trees in high elevations. But these activities are becoming increasingly uncommon due to a lack of knowledgeable people. Many of the plant uses listed in the table above have been replaced with imported goods and services due to globalization. The effects of globalization result in loss of culture from the disuse of traditional plants and cultural practices. As people adopt western ideas and customs, they lose the concepts of ancient Samoan culture (fa asamoa).

Other culturally significant resources: The ancient star mounds in Samoa are massive stone platforms known as tia built by the ancient Samoans as pidgeon trapping sites. They serve a cultural role in ancient Samoan society and are of great importance in religious and ritual practices. The Pacific pigeon (lupe), Samoa's royal bird, is the largest forest bird and is the only one able to transport large seeds of the natural rainforest trees. The habitat of the lupe has been reduced as the natural forest has been cut down; therefore, a ban on hunting the lupe is in place to preserve the remaining populations.

Wilderness: There is currently no wilderness designation for NPSA but there is a potential for wilderness lands on the island of Tau. Designation would provide a mechanism for preservation of significant resources and reduce potential impacts from human encroachment.

USAR

Culturally Significant Resources: The submerged warship lost in World War II remains a critical resource due to the 900 US sailors who lost their lives aboard the ship. This tomb is designated as a National Historic Landmark with the highest level of national historic significance. The memorial serves as a place were visitors can go to honor and remember those who fought and sacrificed their lives during the attack on Pearl Harbor. Natural resources include the organisms attached to the hull, which are providing structural stability for the sunken ship and assisting in preservation of the national shrine.

KALA

Ecological Zones: Special Ecological Areas (SEAs) have been designated to preserve native plants and animals in the most intact diverse, unique and manageable sites in the park. There are eight SEAs within Kalaupapa including the coastal spray zone on the northeast shore of the peninsula, Puu Alii Natural Reserve Area, Waikolu Valley, the Kauhako Crater, caves and lava tubes, the Kauhako Trench/Lava Tube, the cliffs (pali), and the submerged lands surrounding the peninsula.

Viewscapes: Spectacular views can be noted by the immense cliffs, 2000-3000 feet, separating the peninsula from the rest of Molokai. These cliffs along the northeast shore are a National Natural Landmark (1972). They are the result of a gigantic landslide occurring some 400,000 years ago. In addition, three steep narrow valleys bordering the cliffs are the Waikolu, Waialeia, and Waihanau, which were cut in and formed by stream erosion. Offshore islands can also be viewed from Kalaupapa enhancing the viewscape. The Kauhako volcanic crater is another element of the pristine viewscape Kalaupapa has to offer. The crater is a remnant of the Puu Uao volcano, which uplifted from the sea floor about 230,000 years ago. The crater, located at the rim of the volcano, contains a crater lake more than 800 feet in depth. These features of the landscape provide an unspoiled experience for visitors as well as an excellent illustration of natural history.

Culturally Significant Resources: The Hansen's Disease patients, who inhabit the area of Kalaupapa are the primary cultural resource for the park. The history of Kalaupapa dates back 900 years ago when native Hawaiian people inhabited the area. The entire area contains several thousand historical features such as rockwalls, (which were used during the historical period by the Hawaiians as an agricultural field system), cemeteries, churches, concrete house platforms, clusters of buildings, and coconut groves. These resources depict how humans adapted to and interacted with the environment. Many of the historical places and features reveal the uses and the lifestyles of the people of Kalaupapa in earlier times as they relate to the Hansen's disease patients. These cultural resources are directly tied to the prehistoric inhabitants who relied on both marine resources and subsistence agriculture.

Soundscapes: There is an airport located inside the park on the tip of the peninsula. The park is currently in the process of gathering sound levels information for the upcoming Air Tour Management Plan (ATMP).

Lightscapes: Night sky has not been adversely affected by light pollution. The shoreline remains dark with no significant impacts to marine resources. Likewise, terrestrial ecosystems have had no known significant impacts from light pollution.

HALE

Viewscapes: The views and vistas of Haleakala's pristine landscape can be noted from various locations through out the park including the summit area in the aeolian zone, scenic lookouts, and along hiking trails in the Kipahulu District, and throughout the park.

Gradients and Zonation: The Biosphere Reserve was designated in 1980, with the purpose of conserving important biological resources, development of environmental sound economic growth, and support for research, monitoring, education and information exchange related to conservation issues. This strategy involves zoning regional landscapes into areas that range from

total protection with minimal human activity (Kipahulu Research Area) to areas of intensive human use.

Soundscape: Although there is currently no ATMP for the park, there is a gentlemen's agreement with the ATO's for no fly zones at the summit area to reduce significant impacts on natural resources.

Wilderness (designated): Haleakala crater, Koolau and Kaupo gaps, and the Kipahulu Valley, above the level of Palikea Peak (600 meters), comprise the Haleakala Wilderness Area.

The Kipahulu District, consists of 10,600 acres and holds some of the most pristine habitat in Hawaii having up to 95% endemic species in the upper elevations, and includes old growth Hawaiian forest.

The upper portions of Koolau and Kaupo gaps comprise parts of the summit district. This area is best known for its scenic volcanic landscape and the endemic Haleakala silversword. Common shrubs include mamane (*Sophora chrysophylla*), pukiawe (*Styphelia tameiameiae*), pilo (*Coprosma montana*), Ohelo (*Vaccinium reticulatum*), aalii (*Dodonea viscosa*) and kupaoa (*Dubautia menziesii*). Grasses include (*Deschampsia nubigena)*, pili uka (*Trisetum glomeratum*), and (*Agrostis sandwicensis*).

Kipahulu Research Natural Area: The native koa (*Acacia koa*) dominates the forest from 600 to about 1,200 meters, while the `ohi`a (*Metrosideros polymorpha*) dominates the forest above 1,200 meters. A rich variety of subcanopy species exist throughout the valley, especially in the mid-elevation (900 to 1,500 meter) range. Tree ferns (*Cibotium spp*.) are important in the understory. Lobelioids (*Cyanea spp*., *Clermontia spp*., *Lobelia spp*., and *Trematolobelia macrostachys*) and mints *(Stenogyne spp*. and *Phyllostegia spp*.) are among the rare and spectacular endemic plant species of the valley. Kipahulu valley also provides an important flyway for the endangered `U`au and may contain breeding areas yet to be discovered. Kïpahulu Valley also hosts large numbers of endemic invertebrate species.

Culturally Significant Resources: Haleakala is culturally and spiritually important to Hawaiians. The areas comprising HALE have been traditionally used by Hawaiians for a wide range of activities from pre-contact (i.e., before 1778) times up to the present day. These areas also have a history of use by non-Hawaiians and Federal agencies. Although the cultural resources inventory for the park is far from complete, HALE cultural resources include archeological resources, historic structures, museum objects, cultural landscapes, and ethnographic resources. Culturally significant resources include the approximately 3-acre Kapahu Farm, an ethnographic resource, located in the Kipahulu area of the park. At the farm traditional Hawaiian agriculture is being practiced and demonstrated to visitors by the Kipahulu Ohana under a Cooperative Agreement with the park. Five Level 0 cultural landscapes have been currently identified in the Summit area of the park— 1) Hosmer's Planting Areas which is associated with experimental timber forest planting at high altitudes on Maui in the early 1900s; 2) the Park Road built between 1933 and 1953; 3) the Park Headquarters Area which is the site of the earliest park service structures and the Civilian Conservation Corps (CCC) camp; 4) the Crater Trail system, including the back-country cabins, which were built by the CCC; and 5) the Park Maintenance/Resource Management Area which was the base camp for military personnel stationed at military facilities located on Red Hill during World War II.

Historic District: Two historic districts that have been defined for HALE-the Crater Historic District which is listed in the National Register of Historic Places (NRHP), and the Kipahulu Historic District which is eligible for listing in the NRHP.

ALKA

Environmental Gradients & Zones: The 175-mile historical trail passes through diverse ecosystems which include significant natural resources. Due to the nature of the trail along the coastline, most of the natural resources are marine based. Native damselflies, birds, and native bees along with rare plants and animals are known to be associated with anchialine pools and other wetland areas. Other marine organisms include endangered sea turtles, Hawaiian monk seals, and humpback whales. In addition, beaches and intertidal areas provide habitat for migratory shorebirds to forage and rest.

Land Use: The park also provides a recreational beach and shoreline activities including fishing, diving, and collecting resources for food purposes.

Culturally Significant Resources: Historically the trail has been associated with many population centers of the island, especially the royal centers and most major temples. Therefore, the cultural landscape has distinctive Hawaiian resources including a variety of heiaus, fishing settlements and gardening terraces. Along the trail there are also stone surfaces for which games have been played (e.g. konane) ancient game resembling checkers and long inclined basalt tracks,(holua slides), used by the alii as a competitive game to test their courage and skill. Anchialine pools containing significance resources such as the native damselfies (*Magalagrion sp*.) and possibly rare shrimp can be found along the trail system and have been used by the ancient Hawaiians practicing aquaculture (Dunbar 1997).

Lightscapes: The lightscapes along the Ala Kahakai are subjected be degradation as the trail passes through several resorts within the south Kohala coastal region. Outdoor lighting is common along the beaches and poses a threat for nesting sea turtles such as the endangered hawksbill.

PUHE

Culturally significant vegetation: Although most of the vegetation presently located inside park boundaries and on nearby adjacent lands are introduced species such as kiawe, buffelgrass, haole koa, and lantana, there are some native species growing. According to the survey conducted in 1992-1994, (Pratt & Abbott 1996), Ilima, a native shrub, is known to grow away from the coast in vicinity of the heiau and a rare native fern, pololei (*Ophioglossum polyphyllum*), which has been classified in the past as a threatened and endangered plant species, has been identified growing in a isolated area east of Puukohola heiau. This fern has been listed in the past as Category 1 by the U.S. Fish and Wildlife Service, which supports the biological appropriateness to list as endangered species, but has since been removed (Smith 1993) due to proper identification and distribution in other areas. Other natives found growing along coastal areas are naupaka kahakai, milo, pohuehue, and akulikuli. These plants are “hardy” and are likely to spread as the removal of the kiawe continues. Another native plant with significant cultural ties is pili. At the time of the survey, it was found in only one site, but is not uncommon to the area as it has been used for thatching in ancient times. Pili grass has been replanted along the old Spencer Beach Park road and 100 yards north of the visitor’s center.

Cultural landscape: The entire site at PUHE has strong ties with Hawaiian history and Kamehameha the Great. The Puukohola *heiau*, Mailekini *heiau*, Hale o Ka Puni *heiau* and the John Young homestead are all part of the cultural landscape and included within the historical site. The site is a primary attraction for visitors with the cultural landscape being the most significant resource. Due to the importance of these resources, the heiaus as well as the John Young Homestead have been subject to preservation treatment in an effort to restore and stabilize by the NPS for the *enjoyment of future generations*.

Viewscapes: Much like the cultural landscape, the viewscapes at PUHE consist primarily of the heiaus located on the western slope. The Puukohola heiau located atop "the hill of the whale" is the site's key resource, while the Mailekini heiau is another component of the historical scenic vista. The ideal location to experience the historical integrity of the landscape is from the coastal area. While the views are still remarkable from the water or even the coral flats across the water, the development along the shore has adversely impacted the viewscape from the heiau and the surrounding slopes of the park. The viewscape to the ruins of the John Young homestead has been significantly altered and impacted by the overgrown kiawe. This historic view has lost its integrity and is no longer contributing to the historical vistas. Another critical resource is Pelekane Bay, where the unverified Hale o Ka Puni heiau, is located.

Soundscapes: Park management has been concerned with overflights impacting the heiaus. Vibration seems to be a major concern for the heiaus as they have been constructed without mortar and are highly susceptible to impacts.

Lightscapes: The expansion of the boat harbor has resulted in an increase in light pollution with negative impacts to the natural resources. Turtle nesting is not known to occur at Pelekane Bay but there is always a chance for this type of activity.

KAHO

Land Use: Habitat for native species is greatly affected by adjacent land use. Since the park's founding, the rezoning of lands from conservation to urban by the Hawaii Land Use Commission, has greatly impacted the park. Anchialine pools are known to have high levels of endemism and rely on high-quality surface waters. Increased development has degraded water quality from untreated storm water runoff and a lack of a sewage system. Coral reefs are also an important resource for this coastal park and are greatly impacted by surrounding land use.

Soundscapes: Both the underwater and terrestrial soundscapes have been subjected to anthropogenic noise. Expansion of the Honokohau harbor has increased noise for marine resources. Likewise, noise from the nearby Keahole Airport has direct impacts to terrestrial resources.

Lightscapes: Light pollution from the adjacent harbor significantly impact the endangered Hawksbill turtles as they are known to bask and nest along the beach. Development has also brought on a change in the ambient light levels.

Viewscapes: The ongoing development of lands has impacted the historical viewscapes at KAHO.

Culturally Significant Resources: KAHO is considered a sacred place with many culturally significant resources. There are many significant resources at KAHO including the Kaloko and Aimakapa fishponds, providing habitat for native species, to surrounding structures, heiaus,

house platforms, gravesites, trails, and fishing shrines, which are directly related the ancient Hawaiian fishing customs and beliefs. Anchialine pools also have cultural significance and have been historically used for bathing, and ceremonial uses. The pools are also habitat for native damselfly (*Megalagrion xanthomelas*) and are still accessed by native Hawaiians, with traditional gathering rights, for collecting rare shrimp species.

PUHO

Environmental gradients: Remnants of dryland forest, coastal strand, a salt marsh, anchialine pools, man-made fish ponds, historical resources, coral reefs and sparsely dispersed native fauna and flora are dispersed along the gradients and zones. Plant species found along the coast and near the ponds adjacent to the Great Wall include native trees, sedges, a vine and a sprawling herb. Native trees found along the shoreline include milo (*Thespesi populnea*), hala (*Pandanus tectorius*), and naupaka kahakai (*Scaevola sericea*). Native sedges found near the ponds and the Great Wall consist of makaloa (*Cyperus laevigatus*) and mau'u 'aki'aki (*Fimbristylis cymosa*). The Hawaiian Hoary bat (*Lasiurus cinereus semotus*), one of two native mammals to the Hawaiian Islands, commonly forages for flying insect prey over open areas such as forest clearings, lava fields and nearshore coastal waters such as those found adjacent to the park.

Land Use: Currently lands surrounding PUHO consist mostly of open space. Although trends indicate future development of this area, especially along the coastal area, plans are indefinite and the future is unknown. The park service is still in the process of acquiring the former village of Kiilae (238 acres) located along the southern boundary of the park. This parcel is rich in archeological resources as it has been undisturbed since ancient Hawaiian times.

Culturally Significant Resources: Cultural resources at PUHO include a remnant dryland forest, which was used historically for dry terrace cultivation of crops such as taro, sweet potato, sugar, and *wauke*. There are also sparse patches of traditional plants such as pili grass (used for thatching), ahuhu (*Tephrosia purpurea),* used as a fish poison in tidal pools, and Peperomia, which has been used for medicinal purposes as well as a dye for *kapa* cloth. Marine resources also have cultural significance, such as *opihi*, which has been and continues to be utilized by Native Hawaiians. There is a historic fishing shrine located near the cliffs of Keanaee, which is still used today.

HAVO

Environmental Gradients and Culturally Significant Resources: Data taken from the distribution of permits show collection of plants are mostly Aalii, Liko lehua, Palapalai, and Pukiawe with the majority of collection occurring during the Merrie Monarch Festival for hula-halau purposes. Most plants are collected at the Kipuka Ki area, which is a Special Ecological Area, the Mauna Loa Road above and below Kipuka Ki, southwest side of Kilauea Crater adjacent Crater Rim Drive and Highway 11 west of park entrance. All of the collecting occurring on the dry side of the park and less occurring on the wet side (Langlas 2003).

Table 4.1. Plants with Dye Qualities; HAVO Plant Species

Akala fruit	Rubus hawaiiensis	Olaa Tract, Kipuka Ki, Mauna Loa Strip
Kukui bark	Aleurites moluccana	Mid elev east-open woodland

Noni bark	Morinda citrifolia	Coastal Plain
Ohelo berries	Vaccinium reticulatum	Coastal, Mid elev (east, west), Kipuka Ki, Mauna Loa Strip
Ohia bark	Metrosideros polymorpha	All zones
Olapa berries	Cheirodenron trigynum	Mid elev (east), Olaa Tract
Olomea berries	Perrottetia sandwicesis	Mid elev east-rain forest, Olaa Tract
Uki uki fruit	Dianella sandwicensis	Coastal, Mid elev west, Mid elev east-open woodland, Upper Mauna Loa Strip

Plants with dye qualities have been used by members of halau hula to dye their costumes and also by Hawaiians in the creation of artwork (Langlas 2003).

Table 4.2. Plants for Crafts or Cordage; HAVO Plant Species

Hala	Pandanus odoratissimus	Coastal
Hao	Rauvolfia sandwicensis	
Hau	Hibiscus tiliaceus	
Ie ie	Freycinetia arborea	Mid elev (east), Olaa Tract
Koa	Acacia koa	Mid elev west, Olaa Tract, Kipuka Ki, Upper Mauna Loa
Kou	Cordia subcordata	
Lama	Diospyros ferrea	Coastal, Mid elev west, Mid elev east-open woodland
Milo	Thespesia populnea	Coastal Plain
Niu	Cocos nucifera	
Ulei	Osteomeles anthyllidifolia	Coastal, Mid-elev (west), Mid-elev(east)-open woodland,Kipuka Ki, Upper Mauna Loa
Wiliwili	Erythrina sandwicensis	

More often than not plants used for crafts and cordage are used for non religious purposes (e.g. floor mats, bracelets and baskets). This demand creates an insufficient number of plants in the park, therefore plants of this nature can only be collected with special permission from the superintendent (Langlas 2003).

Table 4.3. Plants for Medicinal Uses; HAVO Plant Species

Kukui nuts	Aleurites moluccana	Mid-elev(east)-open woodland

Kukui bark		
Liko/mu o lehua	Metrosideros polymorpha	
Mamaki	Pipturus albidus	Mid-elev (west), Mid-elev (east)-rain forest, open woodland
Noni fruit	Morinda citrifolia	Coastal Plain
Ohelo	Vaccinium reticulatum	Coastal, Mid elev (east, west), Kipuka Ki, Mauna Loa Strip
Ohelo kaula au	Vaccinium calycinum	
Popolo	Solanum nigrum	Mid-elev (east), Olaa Tract, Kipuka Ki
Uhaloa root	Waltheria americana	Coastal, Mid-elev (west)

Table 4.4. Plants with domestic values; HAVO Plant Species

Aalii	Dodonaea viscosa	Coastal, Mid-elev (west), Mid-elev (east)-open woodland, Kipuka Ki, Upper Mauna Strip
Akia bark	Wikstroemia	Coastal, Mid-elev (west), Mid-elev (east), Kipuka Ki,
Akia fruit		
Iliahi	Santalum ellipticum	Mid-elev (west), Mid-elev(east)-open woodland, Kipuka Ki
Kauna oa pehu	Cassytha filiformis	Mid-elev (east)-open woodland
Koa leaves	Acacia koa	Mid elev west, Olaa Tract, Kipuka Ki, Upper Mauna Loa
Liko lehua	Metrosideros polymorpha	All ecological zones
Liko ohelo	Vaccinium reticulatum	Coastal, Mid elev (east, west), Kipuka Ki, Mauna Loa Strip
Maile	Alyxia oliviformis	Mid-elev(east), Olaa Tract, Kipuka Ki
Mamane	Sophora chrysophylla	Mid-elev(west), Kipuka Ki, Upper Mauna Loa Strip
Ohelo fruit	Vaccinium reticulatum	Coastal, Mid elev (east, west), Kipuka Ki, Mauna Loa Strip
Olona	Touchardia latifolia	Olaa Tract
Pa iniu	Astelia sandwicensis	Mid-elev (east), Olaa Tract

Palapalai	Microlepia strigosa	Mid-elev(east), Olaa Tract, Kipuka Ki
Pala a	Sphenomeris chinensis	Mid elev (east, west), Olaa Tract
Pukiawe	Styphelia tameiameiae	All ecological zones
Uki	Machaerina angustifolia	Mid-elev (east)

All of the plants with domestic values are used as a decorative element for lei making or as cordage to tie leis together (Langlas 2003).

While HAVO has numerous culturally significant resources, the cultural landscape at the Ainahou Ranch is a site used for the Hawaiian endangered nene goose breeding and conservation program. Locally renowned businessman and wildlife conservationist Herbert C. Shipman built the house in 1941 and has been credited with saving the nene goose from extinction

Soundscapes: The natural soundscape has been altered due to commericial air tour operations, park aircraft use, diesel tour buses, highway vehicles, park operations and concessions and other cooperator operations.

Wilderness: Over half of the park has been designated wilderness and has been recognized as an International Biosphere Reserve. These lands provide unique hiking trails and campgrounds. The addition of the 116,000 acre Kahuku Ranch has significantly increased the amount of wilderness for HAVO. Kahuku runs along the southwest slopes of Mauna Loa from 2,000 feet to 13,000 feet in elevation and encompasses diverse native ecosystems, from montane mesic forest and shrubland, to dry forest, to the subalpine and alpine communities above 6,500 feet.

TABLES OF CRITICAL RESOURCES AND STRESSORS FOR LANDSCAPE WORKGROUP

Table 5.1. Critical resources and stressors of WAPA

	Critical Resources	Stressors
WAPA	Gradients/Zonation	Burning/Fires
	Soundscape	Urban Development, Military Sonar Testing
	Lightscapes	Urbanization, Street Lights
	Viewsheds	Invasive Species
	Land Use	Adjacent commercial, industrial & residential development
	Management Zones/Use Areas	Feral Animals
	Culturally Significant Resources	Over fishing

Table 5.2. Critical resources and stressors of AMME

	Critical Resources	Stressors
AMME	Gradients/Zonation	
	Soundscape	
	Lightscapes	Outdoor lighting

	Viewsheds	Storm surge activity
	Land Use	Encroaching development, illegal dumping
	Management Zones/Use Areas	Feral animals
	Culturally Significant Resources	Light pollution

Table 5.3. Critical resources and stressors of NPSA

	Critical Resources	**Stressors**
NPSA	Gradients/Zonation	
	Soundscape	Potential development of landing strip on Ofu
	Lightscapes	
	Viewsheds	
	Land Use	Subsistence Agriculture
	Management Zones/Use Areas	Proposed Development
	Culturally Significant Resources	Subsistence Ag & Fishing

Table 5.4. Critical resources and stressors of USAR

	Critical Resources	**Stressors**
USAR	Culturally Significant Resources	Land use (litter, increased development)

Table 5.5. Critical resources and stressors of KALA

	Critical Resources	**Stressors**
KALA	Gradients/Zonation	Alien vegetation and ungulates, mass wasting
	Soundscape	Airport inside park boundary,air tours, barking deer, myna birds
	Lightscapes	Lighthouse
	Land Use	Dumps
	Management Zones/Use Areas	Marine activity (fishing)
	Culturally Significant Resources	Climate, encroaching vegetation

Table 5.6. Critical resources and stressors of HALE

	Critical Resources	**Stressors**
HALE	Soundscape	Air tours
	Lightscapes	Floodlights from shoreline homes & resorts
	Viewsheds	Visibility
	Land Use	Summit facilities
	Culturally Significant Resources	Visitor impacts, alien vegetation

Table 5.7. Critical resources and stressors of ALKA

	Critical Resources	**Stressors**
ALKA	Soundscape	
	Lightscapes	Light pollution from resorts
	Viewsheds	
	Land Use	Development, visitor impacts, litter
	Culturally Significant Resources	Visitor impacts

Table 5.8. Critical resources and stressors of PUHE

	Critical Resources	**Stressors**
PUHE	Gradients/Zonation	Erosion/Sedimentation
	Soundscape	Overflights
	Lightscapes	Harbor Expansion
	Viewsheds	Non-native vegetation

	Land Use	
	Management Zones/Use Areas	
	Culturally Significant Resources	Overflights, Increased visitation

Table 5.9. Critical resources and stressors of KAHO

	Critical Resources	Stressors
KAHO	Gradients/Zonation	Land use
	Soundscape	Boat Harbor Expansion, Increased visitation
	Lightscapes	Adjacent Boat Harbor
	Land Use	Upslope Development
	Management Zones/Use Areas	Feral Animals
	Culturally Significant Resources	Human activity, traditional gathering

Table 5.10. Critical resources and stressors of PUHO

	Critical Resources	Stressors
PUHO	Gradients/Zonation	Invasive species
	Soundscape	
	Lightscapes	
	Viewsheds	Volcanic smog
	Land Use	Potential development
	Management Zones/Use Areas	Increased visitation
	Culturally Significant Resources	Climate change(rise in sea-level),marine harvest (fishing, collecting)

Table 5.11. Critical resources and stressors of HAVO

	Critical Resources	Stressors
HAVO	Gradients/Zonation	Fires
	Soundscape	Increased air tours
	Viewsheds	Invasive species, air quality
	Land Use	Adjacent lands
	Chemical Info&Odor	Volcanic Emissions
	Management Zones/Use Areas	Demographics
	Wilderness Areas	Adjacent land use, buffer zone, fires
	Culturally Significant Resources	Visitor impacts

MONITORING

PARKS MONITORING

WAPA

Some projects have relationships with Landscape Topic and are documented in this section.

Ecological Gradients: The park is in the process of establishing baseline conditions to document sedimentation (rates and composition) on the island's coral reefs. Managers are trying to better understand the effects of wildfire on tropical savannah grasslands in an effort to best establish management practices for reducing erosion and with the Univeristy of Guam are monitoring erosion rates in both burned and non-burned plots. Stream flow gauging stations at Asan and Namo Rivers measuring peak flows and stages in conjunction with rain events are maintained by the USGS Water Resources Division.

Culturally Significant Resources: A study examining fishing pressure by DAWR in Guam is also underway, and a control site is located within the park. This project is related to culturally significant resources at WAPA and anthropogenic impacts from harvests.

Visitor Use: The majority of visitors (three-quarters) at WAPA are Japanese traveling in tour groups. Statistics report can be generated from the NPS website and used to determine impacts to resources by modeling carrying capacity. http://www2.nature.nps.gov/stats/.

Needs: There is a great need for oral histories from local residents to establish trends related to subsistence agriculture and fishing. Establishing this data will assist park management in long term planning for park resources.

WAPA would also benefit from monitoring outdoor lighting within park boundaries, due to increased urbanization. Light pollution has been documented to impact marine and terrestrial resources (Longcore and Rich 2004).

In addition, baseline conditions are needed for terrestrial (vegetation mapping), freshwater resources and also marine toxicants. Other monitoring needs for the park's most significant resources include coral reefs, native limestone forests, tropical savanna forests and other marine ecosystems.

A survey is needed to determine the extent of submerged cultural resources to determine unexploded ammunition where snorkeling and fishing is occurring.

Additional vascular plant monitoring to augment the recent survey done in 2004 would be useful in determining status and trends of native and non-native plant species.

AMME

The majority of ecological monitoring for AMME is related to water quality and marine projects. Some projects have relationships with the Landscape Topic and are documented in this section.

Ecological Gradients: CNMI Department of Environmental Quality is conducting ongoing monitoring at the artificial wetland inside the park boundary. The purpose of this project is to monitor storm water runoff from a nearby hotel.

Culturally Significant Resources: In addition, the University of Guam is also involved in ongoing monitoring of Tanapag lagoon. Monitoring fisheries harvest is essential to preserving this environment and its resources for future generations.

While most monitoring projects have been conducted outside of park, such as reef fish population survey by CNMI DFW in 1996 and CNMI-DEQ measurements of salinity, fecal coliform, pH, DO, turbidity, nitrates, and orthophosphate in artificial wetland in 1996-1997, the results of the study certainly affect the park.

Needs: There is a need for more information on coral reefs, due to their national and local significance and as possible indicators of global and regional climate change. There is also a need for more information on the wetlands mangroves, particularly the inland mangrove wetland, because it's the only one of its kind in the Mariana Islands. Planned monitoring for the mudflats adjacent to the dump is needed to determine levels of toxicity. In addition, research is necessary for endangered bird species including the Nightingale Reed-Warbler.

NPSA

Culturally Significant Resources: The National Tropical Botanical Garden completed an ethnographic overview and assessment report in April 2003 to monitor the effects of significant plant use and disuse over time. Detailed interviews were conducted (25 hours) with individuals and recorded in effort to better understand cultural practices over the last five decades.

Department of Marine and Wildlife Resources (DMWR) is involved in monitoring territory wide harvest of commercial fish and invertebrates to determine trends in resources. Beginning in 1982, monitoring for pelagic and bottom fish began, while the monitoring of other artisanal and subsistence fisheries has been sporadic.

Ecological Gradients: The American Samoa DMWR has been involved in the long term monitoring of trees to determine new recruits and mortality patterns of trees. DMWR also assist the Coral Reef Ecosystem Monitoring Program which provides information on changes in coral reef ecosystems.

Soundscapes: In December 2001 and 2002 sound recordings were conducted at Mount Lata on Tau Island in an effort to recreate the historic natural soundscape when Polynesia was only populated with seabirds, fruit bats and other native species. The recordings filtered out wind and surf so bird calls could be more easily distinguished. Although this was technically not a form of monitoring, it was a way of documenting presence or absence of the focal species.

Needs: Additional monitoring of harvested resources (marine and terrestrial) and effects to respective ecosystems is needed to determine status and trends as well as provide park managers with scientific information to assist in management decisions.

USAR

Culturally Significant Resources: The Legacy Resources Management Fund Project (No. 02-170) has been designated for research directed to understanding the nature and rate of natural processes affecting the deterioration of the USS Arizona in Pearl Harbor, Hawaii, undertaken and headed by the NPS Submergered Resources Center and USAR. The project is designed to provide a foundation for long-term preservation and management of this immensely significant site (Russell and Murphy 2004). Data collected include wave and current patterns as well as pH, temperature, salinity, dissolved oxygen, oxygen reduction potential and conductivity. Their aim is to determine patterns of these variables in Pearl Harbor over a two-year period and identify any correlations with corrosion rates (Storlazzi et al. 2004). The corrosion process is being measured In Situ using pH and corrosion measurements, and by x-ray diffraction and scanning electron microscope using samples collected from different locations along the sunken vessel. Samples of oil, sediment, water & concretion are all being collected as a part of this study. GPS points are being taken to monitor for movement detection of the hull. Preliminary points were taken in June 2001 followed by a most recent survey done in November 2003. The GPS data collected along with ship plans, maps and photographs are being incorporated into GIS databases.

Visitor Use: USAR has been experiencing well over 1 millions visitors annually since 1982. NPS records recreational visitors to the park with specific methods in place to insure accuracy in the data collection process http://www2.nature.nps.gov/stats/.

Needs: Continued collection of baseline data including wind, wave, and current patterns around the vessel as well as some environmental parameters, such as pH, temperature, salinity, dissolved oxygen, oxygen reduction potential and conductivity to determine and model overall corrosion rates is essential for understanding the varied processes occurring within the sunken ship.

KALA

Ecological Gradients: The following monitoring projects have occurred across ecological gradients. Java Plum removal is being monitored at 6-8 month intervals to determine efficacy for restoration at Kukaiwaa. Low density pig project comparing soil fauna at wet forest sites with low densities of pigs with plots from which pigs have been excluded to see if complete eradication of pigs is necessary for forest recovery. Rare plants of Kauhako Crater have been tagged, measured, and evaluated. Monitoring of resident monk seal, beach and shoreline use, restoration of coastal Pritchardia forest, lowland dry/mesic forest, and coastal strand vegetation are all ongoing monitoring projects. Vegetation mapping in Kauhako Crater is the most recent monitoring project being conducted by USGS.

Soundscape: Some preliminary sound testing was conducted at KALA in May of 2003 by the Natural Sound Program. This information will be primarily used to assess the natural soundscape and provide data for the upcoming ATMP.

Visitor Use: Despite the limited access to the park, KALA experieced 57,759 visitors in 2003. This high number of visitors can be attributed to the natural beauty of the landscape and the serene setting the park offers. Park statistics can be accessed through the NPS website http://www2.nature.nps.gov/stats/.

Needs: There is a great need for monitoring bird populations, hihiwai populations in Waikolu stream, and long-term monitoring of known rare plants, especially in Kauhako Crater, and more detailed monitoring of the Kauhako Crater lake fauna. Monitoring opihi populations along rocky shorelines as well as open ocean fish populations will provide managers with information in formulating a plan to preserve resources for future generations. Other landscape monitoring needs include: monitoring petrels, endangered plants, native forest boundary mapping and the monitoring of all birds throughout the park (abundance and distribution), including native forest bird trends.

HALE

Ecological Gradients: Global climate change is being determined and changes in tree line are being monitored in an effort to monitor ecotone boundaries and gradients.

Visitor Impact: In addition, information on visitor use is being monitored in the crater and Kipahulu districts. The Park Service is collecting information on the total number of vehicles, passengers in vehicles, recreational visitors, as well as information on backcountry and front country use campground facilities.

Soundscape: Acoustical data has been gathered to monitor the natural soundscape for the upcoming air tour management plan.

Needs: Information is needed on the recovering alpine aeolian cinderland, subalpine shrub and grassland, montane bogs, cloud and rain forest, leeward shrublands, mesic and dry forests and

associated ecotones distributed in close proximity along a sharp climatological gradient. In addition, more information is needed on subalpine lakes and associated biota, highly impacted systems which may contain rare threatened and endangered species, perennial and intermittent streams and associated biota and riparian habitat including water quality. Threatened and endangered plant and animal species, distribution and health including endangered bats distribution and health is another area for which information about status and trends is considered necessary. Lastly, the most important issue is the distribution of alien species, mostly plants. As these invasives become more widespread, it is extremely necessary to learn about their presence in the park.

ALKA

Due to the nature of the trail traversing through several parks along the coastal plain, monitoring projects have been occurring concurrently with other West Hawaii park projects. For example, anchialine pools are located along the Ala Kahakai within KAHO, HAVO, and PUHO, therefore ongoing research for these pools can be used for dual purposes. Likewise the monitoring of Pelekane Bay for PUHE is another aspect of where the parks overlap. Another example is the wetland bird population project at the Aimakapa Fishpond.

ALKA is working with the West Hawaii Exploration Academy and University of Redlands on a community project involving GIS to monitor natural and cultural resources along the trail. This project is currently in the design phase and working on protocol development. Monitoring will involve using GPS data in conjuction with GIS and photography.

West Hawai`i Aquarium Project (WHAP) is studying the distribution and abundance of aquarium fishes in 23 sites along the West Hawai`i coast since 1998 to analyze the impacts of aquarium fish collecting and the effectiveness of Marine Protected Areas and Fish Replenishment Areas in Hawaii. Natural Energy Laboratory of Hawaii Authority participates in ongoing monitoring of groundwater, nearshore marine areas, and aquaculture outfalls. This research fulfills NPDES and county permit requirements.

Needs: The most important need for ALKA is to first determine the corridor width. In addition, ALKA would benefit from a collaborative effort of park management and community involvement along segments of the trail to monitor natural and cultural resources. Monitoring the effects of urbanization (land use) on marine and shoreline communities is another need for landscape monitoring. This would include:

- Marine water quality monitoring at strategic points along the 175-mile corridor
- Nearshore groundwater quality monitoring
- Alien vegetation assessments
- General ecosystem status, through indicator communities along coast

PUHE

Visitor Impacts: The park also monitors visitors and tracks the number of vehicles that visit the park. PUHE is the second most visited park in West Hawaii with recent figures averaging 50,000 visitors annually.

Soundscapes: Park Service maintenance personnel started monitoring overflights and helicopters in 1986. The main concern was the impact of vibration on cultural resources, mainly

the heiaus built without mortar. In 2002, it was reported that overflight monitoring by park personnel had not collected any data in the last 5-7 years. Hence, the actually numbers of overflights has significantly decreased with an estimate of 350 overflights annually as opposed to 930 annual overflights that has been previously recorded in recent years.

Ecological Gradients: The Mauna Kea Soil and Water Conservation District (MKSWCD) in conjunction with the United States Department of Agriculture (USDA) and Natural Resource Conservation Service (NRCS)has been conducting on going monitoring of erosion rates, vegetation growth, and precipitation in the watershed using rain gauges in the Makeahua Stream and gulch to determine sedimentation rates in Pelekane Bay. Future projects for the park include monitoring shoreline resources, assessing consumptive use, assessing Kawaihae Harbor impacts on the park including collection of core samples to assess sediment contaminants and to monitor changes in sediment composition and deposition, and debris clean-up.

Viewscapes: During the winter of 1988, a time lapse camera (VHS format) was set up at PUHE during the day to document the surf events off of Kawaihae. This monitoring was done in an effort to track tsunamis. Pete Hendricks a tsunami observer volunteer, who is currently employed at the County of Hawaii has the video footage. He also has air photos (35mm) of Pelekane Bay taken in 1975 when several boats were moored and several other air photos taken in 2000 of black tip reef sharks in the Bay.

Needs: Historical accounts (oral histories from local communites) on vegetation to aid in native plant restoration projects is needed for PUHE. The park also needs to monitor visitor use along the park shoreline with recommendations that will ensure swimmer safety due to the presence of sharks in Pelekane Bay. There is a need to document culturally significant resources in areas of the park that are sensitive to native Hawaiians and deserve special attention and protection. Baseline information for endangered turtle populations to see if adjacent harbor lights have negative impacts would also apply to the landscape topic.

KAHO

Lightscapes: The park has been conducting cooperative green sea turtle monitoring with the National Marine Fisheries Service Marine Turtle Research Program and the Hawaii Preparatory Academy in the park since 1999. In addition, the University of Hawaii at Hilo has recently began sea turtle forage studies, as well as anchialine pool studies.

Wetland bird populations are monitored at `Aimakapa Pond through an agreement with Ducks Unlimited.

Effectiveness of resource management is monitored by recording number of animals trapped in the predator management effort, as well as results of alien plant eradication efforts and native plant propagation.

Previous monitoring by park staff has included shorebird surveys (this has been discontinued, but there are plans to continue).

Soundscapes: The Kula Naia Project has recently launched a underwater sound monitoring project to gather information on the underwater soundscape.

Culturally Significant Resources: International Archaeological Research Institute, Inc. (IARII) has conducted an ethnographic overview study of marine resource utilization of KAHO. The

purpose of the study is to consolidate traditional Hawaiian and scientific marine resource utilization information in order to better understand the cultural and natural resources of the park. The information provided in the study will assist the NPS in helping to perpetuate Native Hawaiian fishing traditions and developing information for public interpretation.

Needs: There is a great need to monitor ground water both inside and outside the park due to continued development in upslope areas and planned resort/golf course development adjacent to the park. There is also a need for water quality research of ponds, pools, nearshore waters and groundwater. Also, population and life history information of marine turtles and endemic waterbirds and inventory of anchialine pool species are other areas to be studied. Other areas include coral reef (algae, coral species and cover, fish, target fish in fisheries), native plant species populations and locations, and pond systems (biotic components). Additional needs for the park, which are planned, include coral reef health (composition, fish numbers, and marine water quality), and groundwater and anchialine pool water quality.

PUHO

Monitoring the distribution and abundance of aquarium fishes in adjacent waters to PUHO has been ongoing by the West Hawaii Aquarium Project (WHAP). The University of Hawaii at Hilo and Washington State University, Vancouver have both been actively involved in this project to estimate impacts of aquarium fish collecting, estimate critical habitat characteristics for adult and juvenile aquarium fishes, document recruitment patterns of aquarium fishes, and evaluate the effectiveness of the Fish Replenishment Area (FRA) plan to increase aquarium fisheries.

Ecological Gradients: In addition, the International Archeological Research Institute was contracted to analyze (royal fish) pond sediment cores. This project will provide a historic and pre-historic perspective on pond conditions and associated flora and fauna as well as assist park management in historic restoration efforts.

The USGS has been monitoring the presence of weeds on major roadsides on Hawaii Island. The purpose of this project is to document the presence of weeds, incipient invaders in and near the park. Early detection will allow resource management to more rapidly address priority weeds, frequency of weed species, new records, and distribution.

Visitor Impacts: Visitor use statistics is also being monitored at the entrance gate to track and record incoming visitors for recreational and cultural activities such as fishing, shellfish collecting and other native Hawaiian traditional activities.

Needs: Baseline water quality data is needed for anchialine ponds, tidepools, springs, waterholes and coastal waters. Additional data is also needed for marine resources especially in coral reef areas outside of park boundary, due to increased human impacts from snorkeling, diving and tourist activities. Population surveys for threatened and endangered species, native (indigenous, endemic, polynesian introduced), invasive and non-invasive plant and animal species is also another need to assist park managers in determining and identifying resources at risk. Information on status and trends of biotic communities in anchialine ponds and coastal strands, especially heavily impacted areas is one more area where additional information is needed.

HAVO

Visitor Impacts: Visitor Statistics at Hawaii Volcanoes National Park are monitored daily, including the number of vehicles, total visits, recreational vehicles, non-recreational vehicles, bus vehicles, campground tents, Volcano House use, Kilauea Military Camp use, Backcountry use at Halape, Kaaha, Keauhou, Mauna Loa Summit cabin, Napau, Pepeiau and the Red Hill cabin. This type of monitoring may be useful to further determine impacts to natural resources.

Soundscapes: There are also a number of monitoring projects the National Park Service is involved in, such as, Overflight Noise for the upcoming ATMP, Air Quality Monitoring, which can be used to assess visibility in relation to historic viewscapes and various vegetation monitoring to track trends in ecological gradients.

The HAVO soundscape monitoring plan is used to regulate human generated noise in natural areas by establishing a baseline for human induced noise. Baseline ambient data has been collected in HAVO using a continuous monitoring system developed by the Volpe Center for low level noise measurements. The system deployed consists of a solar panel array, ultrasonic anemometer and a large foam windscreen and microphone system. The data received will be primarily for the Air Tour Management Plan which is currently in the phase of collecting information for the preparation of an EA to mitigate significant adverse impacts to natural and cultural resources in the park.

Land Use: In addition, Land Use, Land Cover (LULC) data to accurately represent LULC of Hawaii Island has been created by USGS to describe vegetation, water, natural surface, and cultural features on the land surface. LULC data may also be used to classify and monitor development such as residential, commercial, and industrial land use on adjacent lands. This data was created from 1997 DOQ Landsat Imagery.

Culturally Significant Resources: The landscape surrounding the Ainahou Ranch House is managed and monitored by the park service at HAVO primarily for preserving the habitat of the Nene and providing a cultural experience for visitors.

Needs: Although Hawaii Volcanoes is an intensively managed landscape, there are many areas in need of information about status and trends. The Kahuku Ranch addition is one section where baseline surveys are needed to determine status and trends of significant resources. Additional information is needed to assess the natural soundscape and effects from air tours. Other areas in need of information include mesic forest ecosystems on the lower slopes of Mauna Loa, Kilauea and above Kalapana Trail, upper montane, subalpine and alpine ecosystems as koa and mamane colonize native shrubland/grassland and other lowland ecosystems proposed for restoration. In addition, information on culturally significant native communities (e.g. traditional gathering areas and species, and relict dry forest ecosystem and species would be useful to determine the status and trends of the ecosystem.

REGIONAL MONITORING PROGRAMS AND METHODS

LAND USE

GIRAS/Land Study Bureau/USGS Landcover/NOAA-CCAP/HIGAP/USGS NAWQA

NOAA-CCAP Land Cover Classification System starts with three superclasses (1) Uplands (2) Wetlands (3) Water and Submerged Land. These superclasses are then subdivided into classes and subclasses at the second and third levels respectively.

USGS LULC Program is cooperating in a research project with the Environmental Systems Research Institute to collect and integrate land use and land cover data for a standard USGS 1:100,000-scale. The LULC data collection techniques interpreting Landsat Thematic Mapper 30-meter resolution, spectrally clustered images, interpreting 1-meter resolution digital panchromatic orthophoto images and for comparison aggregating locally available large scale digital data of urban areas.

LIGHTSCAPES

Satellite

The United States Airforce Defense Metereological Satellite Program (DMSP) is monitoring the night sky by measuring the upward light flux emitted by the sources on the surface of the earth. The satellite F12 is in a low earth polar orbit and carries an oscillating scan radiometer, the Operational Linescan System (OSL), with a photomultiplier tube (PMT) as detector. The OSL scans a narrow swath of the Earth, about 3,000 km wide, perpendicular to the orbit and as the satellite moves it constructs a bi-dimensional image of the Earth surface.

Astronomical Observatories

Mauna Kea Observatories is currently monitoring the night sky using a “CONCAM” so everything can be viewed above the horizon from its location. It monitors the sky for transience such as meteors, stellar variability and rare transient events. It also acts as a cloud monitor for large telescopes looking only at a small piece of the sky and serves as an educational tool allowing anyone with a web browser to see the night sky at any time.

County monitoring

Hawaii and Oahu counties currently have lighting ordinances regulating light uses. An amendment to Chapter 14 to aid in the conservation of energy and restrict the permitted use of outdoor light fixtures emitting undesirable light rays into the night sky has been designed to address problems with light pollution.

Wildlife programs

U.S. Fish & Wildlife Services (DOFWS) has partnerships with the DLNR, USDA Wildlife Services, USGS Biological Research Division, Ducks Unlimited, and the University of Hawaii

participating in conservation programs in Hawaii and the Pacific Islands. The Service's program has four primary areas of concern (1) Population Assessment (2) International, national and flyway coordination (3) Habitat Management (4) Regulating take.

The DOFWS partnered with the University of Wisconsin, Department of Zoology and conducted a study on the island of Kauai to determine if shielding of lights to prevent upward radiation of the largest resort decreased the number of attractions of Hawaiian seabirds. The results indicated a 40 percent decrease in attraction (Reed et at. 1985). The monitoring was conducted during 1980 and 1981 with diurnal patterns analyzed after sunset.

SOUNDSCAPES

OSHA/health regulations

The OSHA standard states when information indicates that any employee's exposure may equal or exceed an 8 eight hour time weighted average of 85 decibels; the employer shall develop and implement a monitoring program.

Airport

Airport Noise Compatibility Planning-Part 150 prescribes single systems for (a) measuring noise at airports and surrounding areas that generally provides a highly reliable relationship between projected noise exposure and surveyed reaction of people to noise; and (b) determining exposure of individuals to noise that results from the operations of an airport; This part also identifies those land uses which are normally compatible with various levels of exposure to noise by individuals. It provides technical assistance to airport operators, in conjunction with other State, local, and Federal authorities, to prepare and execute appropriate noise compatibility planning and implementation programs.

NEPA

The National Environmental Act of 1969 was designed to eliminate damage to the environment and biosphere and promote the understanding of the ecological systems and natural resources by declaring a national policy to encourage harmony between man and his environment. Mandated by Congress the policies set forth require all federal agencies to follow specific guidelines in accordance with NEPA in an effort to protect and conserve the nation's resources for the benefit of future generations.

Air Tour Managment Plans (ATMP)

The Federal Aviation Administration (FAA) in cooperation with the National Park Service (NPS) has initiated the development of an Air Tour Management Plan (ATMP) for HAVO, HALE, KAHO, PUHE, PUHO, KALA to mitigate or prevent the significant adverse impacts of commercial air tour operations upon the natural resources, cultural resources, and visitor experiences of the subject national park unit. The ATMP is in accordance with the National Parks Air Tour Management Act of 2000, which is required for all those who apply for authority to conduct air tour operations over a park. The ATMP shall be developed by means of a public process to assure all important issues are addressed.

Marine:

Acoustic Thermometry of Ocean Climate Project (ATOC) acquired acoustical data from U.S. Navy SOSUS arrays located throughout the North Pacific. Two sites, one located on Pioneer Seamount off the coast of California and the other north of Kauai were selected to allow much of the acoustical energy to leave the source without the interaction of the ocean bottom. The data is used to accurately determine range and depth averaged ocean temperatures. Studies have been conducted to determine effects on marine mammals. The change in behavior of humpback whales has been subtle when exposed to signals transmitted from (ATOC) sound projector located off the coast of Kauai (Frankel and Clark 2002) It is not certain whether the transmission is affecting the sightings of the whales near the (ATOC) source or changes in sightings reflect population variation in seasonal peaks.

Passive acoustic techniques have been used to identify and locate species distribution in Massachusetts (Cohen 2002). It is also useful in obtaining knowledge of the behavior of fish and examines the impact of anthropogenic (noise) activity, especially on spawning behaviors. Researchers from the University of Massachusetts Dartmouth and the University of Massachusetts at Amherst have recently begun conducting passive acoustic surveys in estuaries of the northeastern United States. These surveys contribute to the census of marine life and are a useful tool for identifying essential fish habitat. Hydrophones are used underwater to convert sound pressure into an electrical signal which is then recorded by a data acquisition system.

Terrestrial:

Photos have been taken documenting the effects of overflights on wildlife, such as the Dall sheep in the Grand Canyon (Lee 1994). Due to the scarcity of data for effects to wildife, this type of monitoring is becoming more popular, to assist in scientific research.

Sampling of bird song was conducted to differentiate between an ambient environment and an environment where transmission experiments were conducted (Slabbekoorn & Smith 2002). Monitoring songbird distribution is strongly tied to habitat structure, Songbirds provide a unique monitoring tool for assessing and detecting changes in the landscape. Species tend to evolve to regulate to their acoustic environment as far as other species voices in the same biome. Bird song is also highly dependent on seasonality, habitat, and gender.

The Department of Defense is required by the Endangered Species Act to collect data on threatened and endangered species for management plans in minimizing impacts of military activities. This monitoring system consists of three components: (1) a microprocessor-controlled digital data recording system that can be deployed either on the ground or on an airborne platform; (2) a helium filled lift vehicle that can carry the recording system aloft for drinking or tethered deployments; and (3) a software package for automatic extraction, identification, and localization of sounds of interests. The completely implemented monitoring system will result in the ability to map sound source locations with a log of species and time of call. Many threatened and endangered species are located in inaccessible areas making traditional transect monitoring difficult. The ability to monitor these areas using acoustics, result in the collection of data to determine presence or absence and estimated population density of target species.

VIEWSHEDS & SCENERY

National Natural Landmark Program

The National Natural Landmark Program recognizes and encourages the conservation of outstanding examples of our country's natural history. It is the only natural areas program of national scope that identifies and recognizes the best examples of biological and geological features in both public and private ownership. National Natural Landmarks (NNLs) are designed by the Secretary of the Interior, with the owner's concurrence. NPS administers the NNL Program, and if requested, assists NNL owners and managers with the conservation of these important sites.

Cultural Landscape Inventories (CLI)

The Olmsted Center for Landscape Preservation provides research, planning, and preservation compliance assistance to help parks inventory, understand, and plan for the management of their cultural landscapes. The CLI is a comprehensive inventory of all culturally and historically significant landscapes within the National Park System. The CLI records each landscape's location, historical development, existing conditions, and management information. For landscapes found to be potentially eligible for the National Register of Historic Places, the CLI provides an analysis of landscape characteristics and features, allowing for an evaluation of historic integrity and significance.

Historic Viewsheds

The principle of the USDA Forest Service Scenery Management System is that land management activities (including construction of facilities) should not contrast with the existing natural appearing landscape. Within a framework of regional landscape character types, form, line, color, and texture should be used to make activities and structures "fit" within landscapes. This approach promotes a strong response to the context of the natural landscape. It also reinforces the concept of early park planning that structures should be visually subordinate to the landscape.

Scenery assessment at the ecoregion scale

There are two elements used with scenery assessment and analysis including landscape character and scenic integrity. Landscape character includes four primary attributes comprising of landforms, vegetation, water forms, and cultural forms. Scenic integrity is the wholeness or intactness of the landscape serving as a baseline measurement for which potential changes can be measured. The methods used in the scenery assessment are 1) Identify landscape themes, as a component of landscape character, at the ecological subsection scale; 2) Evaluate current levels of scenic integrity at the watershed scale (Galiano and Loeffler, 2000).

VISITOR & MANAGEMENT IMPACTS

Visitor Experience and Resource Protection (VERP)

The purpose of the VERP is to address desired conditions for both visitor experience and protecting natural resources. Guidelines and regulations for addressing visitor capacity include the National Parks and Recreation Act, the Wild and Scenic Rivers Act, and the 1982 Wild and Scenic Rivers Guidelines. The VERP framework consists of nine elements (Fig 4.).

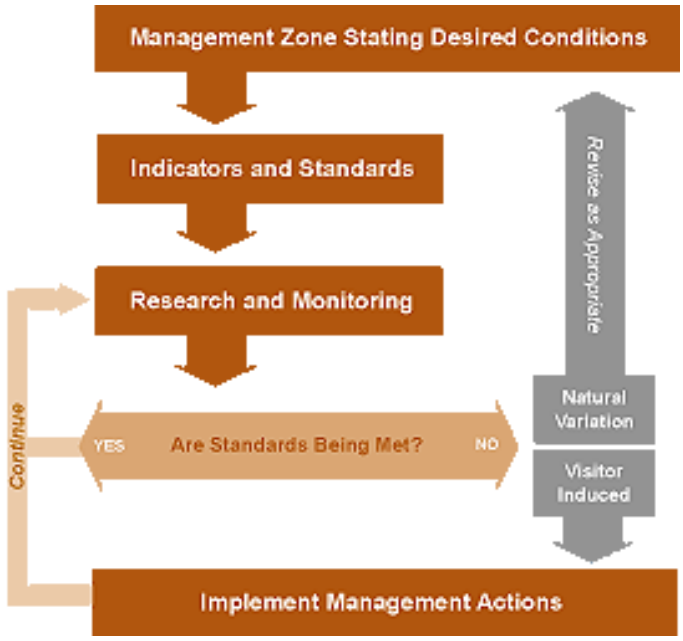

Figure 4. VERP Conceptual Model; NPS Yosemite Planning

The Merced River Plan is an example of a method used to contribute to the management and planning process in Yosemite National Park. The goal of the plan is to allow the natural processes to prevail within the river and the corridor.

Interpretive programs

Interpretive programs provide the education to preserve and protect cultural and natural resources in an uninhabited state. They help visitors to be accountable and responsible for their actions when visiting natural areas. NPS interpretive programs is a method used by the park service to offer visitors the opportunity through wayside exhibits, viewing audio-visual, museum objects, park guided tours through trials and forested areas, to gather information pertaining to the traditional native culture and practices with a basic understanding and introduction to the significant and unique natural and cultural resources the park has to offer.

Demographic and cultural profiles of visitors

Cultural profiles of visitors to the National Parks vary from park to park. The larger more developed parks tend to experience more recreational visitors from tourists than smaller less developed parks, where indigenous people visit for culturally reasons. Statistic reports can be accessed from the NPS website http://www2.nature.nps.gov/stats/.

MANAGEMENT ZONES & USE AREAS

The framework for management zoning had been designed to meet the needs of all National Park units. Zoning categories are based on the location of historically significant resources and objects, nature resource values, and patterns of visitor use. Zoning provides the basis for future management and use needs.

Wilderness

Undeveloped forested areas are often designated and classified as wilderness lands. Access to these areas is permitted with restrictions in place in an effort to preserve the natural ecosystem. Parks with designated wilderness lands are required by wilderness management policies to prepare a wilderness management plan. The purpose of the plan is to guide the management of resources, visitor and administrative use, and research in the wilderness, provide guidelines, standard operating procedures, and decision-making tools for meeting legislative and NPS policy mandates to protect wilderness qualities in the park, and ensure the continuity of wilderness management philosophy and management as park staff and managers change.

Limits of Acceptable Change has been initiated in the Arches National Park and served as the pilot for other parks such as Glaicer National Park in Montana. It provides the basis for general management in National Parks and assists in the planning efforts to address the issues surrounding visitor use. The major features of Limits of Acceptable Change include Visitor Impact Management (VIM), Visitor Experience and Resource Protection (VERP), and (LAC) (McCool and Cole 1997). The recording of conditions over time can help to evaluate management plans and address problems. The process outlines issues for recreational development and management. This course of action is needed for National Parks to preserve the important values for which they have been recognized.

CULTURALLY SIGNIFICANT RESOURCES

The State Historic Preservation Division (SHPD) of Department of Land and Natural Resources (DLNR) works to preserve and sustain remainders of earlier times which links the past to the present. The Statewide Historic Preservation Plan for the State of Hawaii has been developed to provide a vision for historic preservation within the Island chain, and to outline a future direction for the SHPD and its myriad preservation partners. Hopefully, it will serve as a guide for effective decision making on a general level, for coordinating historic preservation activities within Hawaii, and for communicating statewide historic preservation goals, policies and objectives. In addition, the Cave Protection Act protects caves, and the unique cultural and natural resources inside them, of the State of Hawaii. Caves are inhabited with specialized organisms, native flora and fauna living within the entrances, mineral and bedrock formation, and paleotological or fossil deposits (remains of plants, animals, and surface debris).

CONCLUSION

The stratification of the landscape topic is a relatively new concept. This grouping allows for monitoring to occur across multiple scales while integrating natural resources and cultural values. NPS is involved in numerous projects (e.g. Air Tour Management Plans) used to develop a comprehensive plan for national parks. The NPS is mandated by legislation laws, which

provide a framework for landscape monitoring. Information from various ongoing monitoring projects can be used by NPS to provide other parks in the PACN a plan for undertaking similar projects as they apply to respective parks and natural resources.

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LITERATURE CITED

Amesbury, S. 1999. Fish Surveys of War in the Pacific NHP. NPS Technical Report.

Apple, R. A. M., Gordon A. 1976. The rise of sea level in contemporary times at Honaunau, Kona, Hawaii : and , 1966. Pacif. Sci., 20 (1): 125-136. Deep Sea Research and Oceanographic Abstracts **13**:1015.

Baker, R. H. 1951. The avifauna of Micronesia, its origin, evolution, and distribution. University of Kansas Publications, Museum of Natural History 3(1): 1-359.

Banko, P. 1988. Breeding Biology and Conservation of the Nene, Hawaiian Goose (Nesochen sandvicensis). A dissertation submitted in partial fulfullment of the requirements for the degree of Doctor of Philosophy. University of Washington.

Bazzano, Jason. 2004. West Hawaii Herpetological Survey, unpublished report, Inventory and Monitoring Program files, National Park Service, Hawaii Volcanoes National Park.

Blumenstock, D. I., and S. Price. 1967. Climates of the states: Hawaii. Environmental Science Data Service, Climatology of the United States, No 60-51. U. S. Government Printing Office, Washington, D. C. 27 pp.

Brasher, A. M. D. 2003. Impacts of Human Disturbances on Biotic Communities in Hawaiian Streams. BioScience **53**:1052-1060.

Canfield, J. 1990a. Description and map of the plant communities of Kaloko-Honokohau National Cultural Park. Cooperative National Park Resources Studies Unit Technical Report 73. University of Hawaii at Manoa, Department of Botany, Honolulu, Hawaii.

Chapin, F. S. III, M. S. Torn, and M. Tateno. 1996. Principles of ecosystem sustainability. American Naturalist **148**:1016-1037.

Cohen, Andrea. (editor) Listening to Fish: Proceedings of the International Workshop on the Applications of Passive Acoustic in Fisheries. Hosted by MIT Sea Grant 2002. 188 pp. http://web.mit.edu/seagrant/aqua/cfer/passiveacoustics/passiveacoustics.html accessed February 15, 2005.

Cole, D. N., and P. B. Landres. 1996. Threats to Wilderness Ecosystems: Impacts and Research Needs. Ecological Applications **6**:168-184.

De Fries, Ruth. S., J. A. Foley, and G. P. Asner. 2004 Land Use choices: balancing human needs and ecosystem function. Frontiers in Ecology and the Environment **2**:249-257.

Dotinga, H. M. O. E., Alex G. 2000. Acoustic Pollution in the Oceans: The Search for Legal Standards. Ocean Development & International Law **31**:151-182.

Dunbar, H. R. 1997. Determining Significance Hawaii's Ala Kahakai. Cultural Resource Management **20**.

Environmental Protection Agency. 1971. Effects of Noise on Wildlife and Other Animals. Prepared by Memphis State University under Contract 68-04-0024, December 31, 1971.

Frankel, A. S., and C. W. Clark. 2002. ATOC and other factors affecting the distribution and abundance of humpback whales (Megaptera novaeangliae) off the north shore of Kauai. Marine Mammal Science. Vol. 18, no. 3, pp. 644-662. Jul 2002

Giambelluca, T. W., M. A. Nullet, and T. A. Schroeder. 1986. Rainfall atlas of Hawaii. Report R76. Water Resources Research Center, University of Hawaii at Manoa with the cooperation of the Department of Meteorology. State of Hawaii, Department of Land and Natural Resources, Division of Water and Land Development, Honolulu, Hawaii.

Gawel, M. J. 1999. Protection of marine benthic habitats in the Pacific islands. A case study of Guam. Oceanologica Acta **22**:721-726.

Gomez-Pompa, A. 2004. The Role of Biodiversity Scientists in a Troubled World. BioScience **54**:217-225.

Hawkins, J. P., and C. M. Roberts. 1993. Effects of Recreational Scuba Diving on Coral Reefs: Trampling on Reef-Flat Communities. Journal of Applied Ecology **30**:25-30.

Hill, H. B. 1978. Use of nearshore marine life as a food resource by American Samoans. Pacific Islands Studies Program, UH.

Hughes, T. P., and J. H. Connell. 1999. Multiple Stressors on Coral Reefs: A Long-Term Perspective. Limnology and Oceanography **44**:932-940.

Galliano, Steven. J., and L. G. M. Loeffler. 2000. Scenery Assessment: Scenic Beauty at the Ecoregion Scale. General Techical Report PNW-GTR-472, U.S. Department of Agriculture Forest Service Pacific Northwest Research Station, Portland.

Janni, K. 2002. Plants in Samoan Culture. The Ethnobotany of Samoa. Economic Botany **56**:100-100.

Juvik, Sonia. P., and J. O. Juvik. 1998. Atlas of Hawaii. University of Hawaii at Hilo, Dept. of Geography. Third Edition.

Kaye, Glen. 1996. Demographics and resource preservation. Natural Resource Year in Review. National Park Service, U.S. Department of the Interior, in May 1997 (publication D-1182).

Kelson, A. R. 1998. Integrating wilderness within broader landscapes: the U.S. public land experience. Land Use Policy **15**:181-189.

Knight, A. 2004. Personal Communication regarding commercial air tours at Hawaii Volcanoes National Park.

Langlas, C. M. 2003. Ethnographic studies at Hawaii Volcanoes National Park. National Park Service. 142 p.

Langlas, C. M. 2003. Native Hawaiian Use of Hawaii Volcanoes National Park: A Historical and Ethnographic Overview. National Park Service.

Lavendel, B. 2002. Preserving the Peace and Quiet. National Parks.

Lee, D. 1994. Breaking the sound barrier. National Parks **68**.

Lenz, L., and J. A. Taylor. 2001. The influence of an invasive tree species (Myrica faya) on the abundance of an alien insect (Sophonia rufofascia) in Hawai'i Volcanoes National Park. Biological Conservation **102**:301-307.

Li, C. 2000. Reconstruction of natural fire regimes through ecological modelling. Ecological Modelling **134**:129-144.

Loh, R. K., A. Ainsworth, B. Miner, R. Russell, J. Makaike, and T. Tunison. 2000. Mullein Survey Any Removal Efforts On Mauna Loa In Hawaii Volcanoes National Park. Technical Report 126, University of Hawaii at Manoa Pacific Cooperative Studies Unit Department of Botany.

Longcore, T., and C. Rich. 2004. Ecological light pollution. Frontiers in Ecology and the Environment **2**:191-198.

Mace, B. L., P. A. Bell, and R. J. Loomis. 1999. Aesthetic, Affective, and Cognitive Effects of Noise on Natural Landscape Assessment. Society & Natural Resources **12**:225-242.

MacDonald, G. A., and A. T. Abbott. 1970. Volcanoes in the sea; the geology of Hawaii. University of Hawaii Press, Honolulu, Hawaii.

McCool, S. F. C., David N. 1997. Proceedings-Limits of Acceptable Change and related planning processes: progress and future directions. Pages 84 *in*. Rocky Mountain Research Station (Ogden, Utah 324 25th St., Ogden 84401).

McDermid, K. J., and T. L. McMullen. 2004. Quantitative analysis of small-plastic debris on beaches in the Hawaiian archipelago. Marine Pollution Bulletin **48**:790-794.

Moore, R. B., D. A. Clague, M. Rubin, and W. A. Bohrson. 1987. Hualalai volcano: a preliminary summary of geologic, petrologic, and geophysical data. Pp. 571-585 in R. W. Decker, T. L. Wright, and P. H. Stauffer (editors). Volcanism in Hawaii, Vol. 1. U. S. Geological Survey Professional Paper 1350. U. S. Government Printing Office, Washington, DC.

Mueller-Dombois, D., and F. R. Fosberg. 1998. Vegetation of the tropical Pacific islands. Springer-Verlag, New York.

NPS. 2003. Park Vital Signs Monitoring. A commitment to resource protection, National Park Service Brochure.

National Park Service. 1993. VERP: A process for addressing visitor carrying capacity in the national park system. Pages 20 *in*. National Park Service.

Pacific Island Network. 2002. Pacific Islands Network Vital Signs Monitoring Survey: Results Compilation. *in*. I&M staff.

Parrish James, D., C. Smith Gordon, and N. J. E. 1990. Resources of the Marine waters of Kaloko-Honokohau National Historical Park. Technical Report 74, University of Hawaii Manoa Department of Botany.

Prato, T. 2001. Modeling carrying capacity for national parks. Ecological Economics **39**:321-331.

Raulerson, L. 1979. Terrestrial And Freshwater Organisms Within, And Limnology And Hydrology Of, The Guam Seashore Study Area And The War In The Pacific National Historical Park. University of Guam, Department of Biology.

Reed, J. R., J. L. Sincock, and J. P. Hailman. 1985. Light Attraction In Endangered Procellariiform Birds: Reduction By Shielding Upward Radiation. The Auk **102**:377-383.

Rodgers, K. S., and E. F. Cox. 2003. The effects of trampling on Hawaiian corals along a gradient of human use. Biological Conservation **112**:383-389.

Russell, M. A., and L. Murphy. 2004. Long-Term Management Strategies for the USS Arizona: A Submerged Cultural Resource in Pearl Harbor, Hawaii. National Park Service Submerged Resources Center and USS Arizona Memorial Legacy Resources Management Fund Project No. 03-170, Santa Fe, New Mexico.

Sheeline, L. 1991. Cultural Significance of Pacific Fruit Bat (Pteropus spp.) to the Chamorro People of Guam: Conservation Implications. World Wildlife Fund/Traffic USA.

Slabbekoorn, H., and T. B. Smith. 2002. Habitat-dependent song divergence in the little greenbul: an analysis of environmental selection pressures on acoustic signals. Evolution **56**:1849-1858.

Smith, G. C., A. P. Covich, and A. M. D. Brasher. 2003. An Ecological Perspective on the Biodiversity of Tropical Island Streams. BioScience **53**:1048-1051.

Smith, S. V., and R. W. Buddemeier. 1992. Global Change and Coral Reef Ecosystems. Annual Review of Ecology and Systematics **23**:89-118.

Storlazzi, CD, Russell, MA, Owens, MD, Field, ME, and Murphy, LE, 2004. Dynamics of the physical environment at the USS Arizona Memorial: 2002-2004. U.S. Geological Survey Open-File Report 2004-1353.

Thomas, D. M. 1986. Geothermal resources assessment in Hawaii*1. Geothermics **15**:435-514.

Whistler, W. A. 1992. Botanical inventory of the proposed Tau unit of the National Park of American Samoa. Cooperative National Park Resources Studies Unit Technical Report 83. University of Hawaii at Manoa, Department of Botany, Honolulu, Hawaii

Whistler, W. A. 1994. Botanical inventory of the proposed Tutuila and Ofu units of the national Park of American Samoa. Cooperative National Park Resources Studies Unit Technical Report 87. University of Hawaii at Manoa, Department of Botany, Honolulu, Hawaii.

Whistler, A. W. 2000. Plants in Samoan Culture: The Ethnobotany of Samoa. Isle Botanica.

Wolanski, E., R. H. Richmond, G. Davis, and V. Bonito. 2003. Water and fine sediment dynamics in transient river plumes in a small, reef-fringed bay, Guam. Estuarine, Coastal and Shelf Science **56**:1029-1040.

Wolanski, E., R. H. Richmond, and L. McCook. 2004. A model of the effects of land-based, human activities on the health of coral reefs in the Great Barrier Reef and in Fouha Bay, Guam, Micronesia. Journal of Marine Systems **46**:133-144.